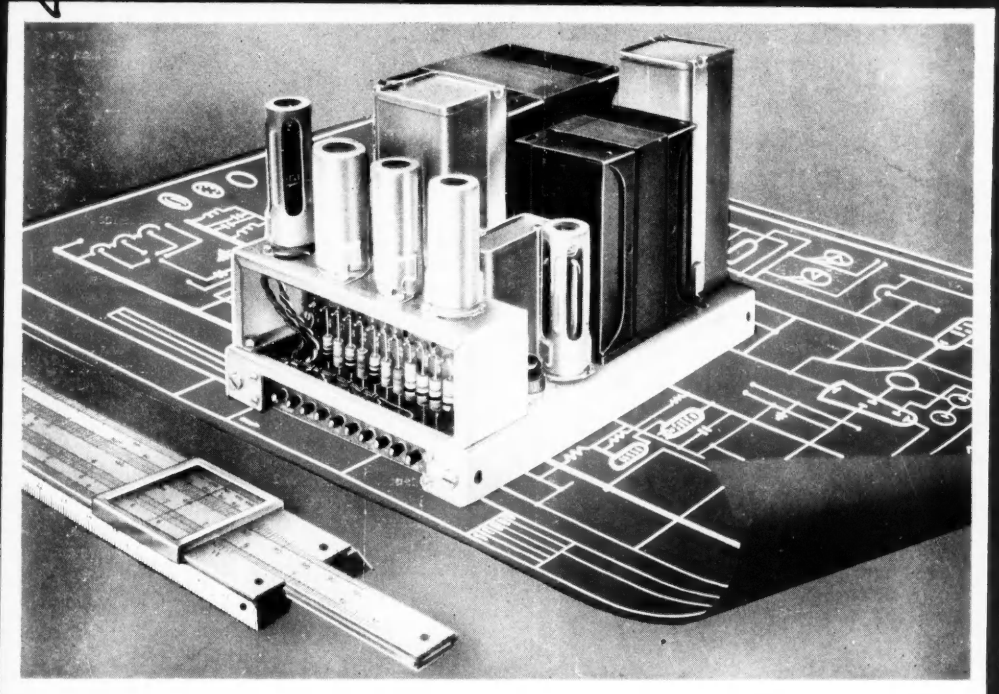
Electronic Engineering



SOLARTRON *POWER SUPPLY SUB-UNITS*

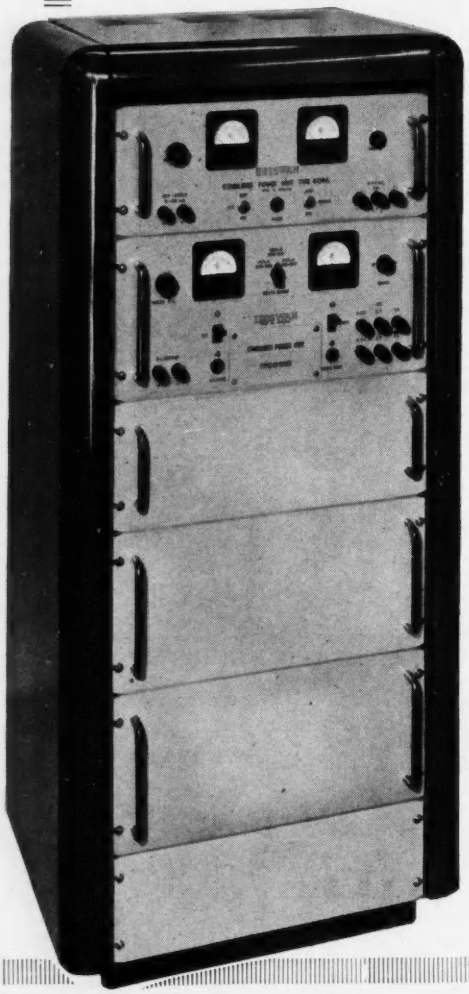
save you weeks of design time per project

TWO SHILLINGS

EDISWAN

Stabilised Power Supply Units

Staffs of Electrical and Electronic Laboratories and Test Rooms frequently design and construct their own units for supplying stabilised D.C. power; but for most general needs it is cheaper and more satisfactory to purchase an Ediswan Unit. Type R.1095 covers the range 120-250 volts, and type R.1103 250-400 volts. Both units work from A.C. mains supply and are designed for standard 19″ rack mounting or for bench use. Meters are included.



PRICES

R.1095	£27 - 10 - 0
R.1103	£57 - 0 - 0

Full details on request

BRIEF SPECIFICATIONS

Type R.1095

Input.	200-250 volts, 40-100 c.p.s.
Output.	High stability, D.C. output 120-250 volts at 0-50 mA and an unstabilised 6.3v. A.C. 3 amp. heater supply.
Stability.	A 10v. change in mains input results in an output change of less than 0.15 volts.
	A change from zero to full load results in an output change of less than 0.15 volts.
Output Resistance.	Less than 3 ohms.
Ripple.	Approximately 2mV R.M.S.
Output Circuits.	All circuits isolated from earth. Heater supply can be operated at up to 500 volts from earth.
Mounting.	The unit is designed for standard rack mounting or for bench use. Plated bench stands are available if required.

Type R.1103

Input.	200-250 volts, 40-100 c.p.s.
Output.	High stability, D.C. output 250-400 volts, adjustable in three ranges. Maximum load is 200 mA up to 350 volts and 150 mA from 350 volts to 400 volts.
	In addition two unstabilised 6.3 volt A.C. heater supplies are provided.
Stability.	A 10 volt change in mains input voltage results in an output change of less than 0.15 volts.
	A change from zero to full loads results in an output change of less than 0.4 volts.
Output Resistance.	Less than 2 ohms.
Ripple.	Approximately 5mV R.M.S.
Output Circuits.	All circuits isolated from earth. Heater supply can be operated at up to 500 volts from earth.
Mounting.	The unit is designed for standard rack mounting, or bench use.

Illustration shows Ediswan Stabilised Power Supply Units type R.1095 and R.1103, rack mounted.

THE EDISON SWAN ELECTRIC CO. LTD. 155 CHARING CROSS ROAD, LONDON, W.C.2

Telephone: Gerrard 8660 · *Member of the A.E.I. Group of Companies* · Telegrams: Ediswan Westcent, London

8P114

mA
ply.
t

an

able
o
ts.
f

an

,

Supply

.

W.C.2
London
SP114

1954

CLASSIFIED ANNOUNCEMENTS

The charge for these advertisements at the LINE RATE (if under 1" or 12 lines) is: Three lines or under 7/6, each additional line 2/6. (The line averages seven words.) Box number 2/- extra, except in the case of advertisements in "Situations Wanted," when it is added free of charge. At the INCH RATE (if over 1" or 12 lines) the charge is 30/- per inch, single column. Prospectuses and Company's Financial Reports £14. 0s. 0d. per column. A remittance must accompany the advertisement. Replies to box numbers should be addressed to: "Electronic Engineering," 28, Essex Street, Strand, London, W.C.2. Advertisements must be received before the 14th of the month for insertion in the following issue.

OFFICIAL APPOINTMENTS

ADMIRALTY—ROYAL NAVAL SCIENTIFIC SERVICE. Experimental Officers and Assistant Experimental Officers required in Experimental Establishments in London, Portsmouth, Weymouth areas, Gloucestershire and Scotland. The majority of posts are for Engineers and Physicists (particularly with Electronics). Candidates must be British subjects. Qualifications — minimum of H.S.C. (Pass Degree, H.N.C. or near equivalent an advantage) London salary (men) E.O. £720-£890—A.E.O. (according to age) £290-£645. All appointments are unestablished, but with some opportunities to compete for established posts. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A247/52A. W 2219

ADMIRALTY: TECHNICAL CLASSES. The Civil Service Commissioners announce a Reconstruction Competition for men to fill about ten posts as Development Assistants at the Admiralty Engineering Laboratory, West Drayton, Middlesex. The duties involve experimental and development work in connexion with the electrical equipment of warships. Age at least 26 on 1st August, 1954. Candidates must have served an engineering apprenticeship or have had equivalent workshop experience. They must possess O.N.C. (preferably H.N.C.) in Electrical and/or Mechanical Engineering or acceptable equivalent, followed by six years adult experience including at least three years experience in work requiring the qualifications referred to above. Salary scale £650 (at age 30) to £761. Starting salary according to age, e.g., £570 (at 26) up to £761 (at 36 or over). Promotion prospects. Further particulars and application forms from Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting No. S 262/54. Completed application forms must be returned by 8th July, 1954. W 2210

AIR MINISTRY requires Scientific Officers for Operational Research on a wide variety of problems, in London and provinces, under direction of Scientific Adviser to Air Ministry. Qualifications: First or Second Class Honours Degree or equivalent, in Mathematics or Physics. Salary: (London) within range £470-£855. Provincial rates and rates for women somewhat lower. Posts unestablished, with possibilities of establishment through the Civil Service Commission, for successful candidates while remaining under age 31. Application forms, quoting A285/52/A from M.L.N.S. Technical and Scientific Register (K), 26 King Street, London, S.W.1. (Closing date 13th August, 1954.) W 2241

B.B.C. requires Engineer with University Degree in Electrical Engineering or Physics or equivalent, for Field Strength Section of Research Department at Kingswood, Surrey, but involving frequent and long absence for radio frequency measurement throughout British Isles. Experience of transmitters, aerials, measurement and use of receiving equipment desirable, knowledge of VHF/UHF techniques an advantage. Salary £645 rising to £880 p.a. in five years. Applications stating age, education, qualifications and full details of experience to E.E.O., B.B.C. London, W.1, quoting Ref. E.923 within seven days. W 2192

BRITISH EUROPEAN AIRWAYS require a Technical Officer (Navigational Aids) at Northolt. Duties include planning and reporting on flight trials and on ground navigational facilities, investigations and development. Essential qualifications: Physics Degree or equivalent; sound knowledge of aircraft radio and operational applications; experience desirable in evaluation of navigational aid systems. Salary scale £785 to £1,025 p.a. Applications stating full details to Personnel Officer, Flight Operations Department, B.E.A., Keyline House, Ruislip, Middlesex. W 2209

BRITISH EUROPEAN AIRWAYS require engineers for the maintenance, overhaul and development of Electronic Flight Simulators. Applicants must have a fundamental knowledge of electronics; experience in the field of servo mechanisms, repeaters and in dealing with large scale equipments is desirable. Salary during familiarization period of six months will be £569 per annum, rising to range £608-£725 per annum. Additional payments made for any required shift working. Written applications to Personnel Officer, Flight Operations Department, B.E.A., Keyline House, Ruislip, Middlesex. W 2159

CANADIAN RED CROSS MEMORIAL HOSPITAL, Taplow, Nr. Maidenhead. Applications invited for post of Technical Assistant in the Special Unit for research in Juvenile Rheumatism, to assist in development of electrical and mechanical recording apparatus. A practical and theoretical knowledge of electronic and mechanical engineering essential. Salary £450 × £15 (3) × £20 (1) — £515 per annum. Applications stating age, qualifications and experience, with copies of three recent testimonials to Hospital Secretary. W 2185

ELECTRONIC ENGINEERS AND PHYSICISTS required by Ministry of Supply Experimental Establishments at Farnborough, Hants; Malvern, Worcs, Sevenoaks, Kent, and elsewhere, mainly in Southern England. Duties include research, development or design of telecommunications and radar equipment guidance and control systems; instrumentation for variety of research problems. Experience of V.H.F.; pulse techniques; display systems, etc., desirable for some posts. Appointments according to qualifications and experience as Scientific Officer (1st or 2nd Class Honours Degree or equivalent) £445-£815. Assistant Experimental Officer (Higher School Certificate (science) or equivalent—Degree or H.N.C. may be an advantage and technical experience in Forces or industry desirable) £276 (age 18) — £615; Experimental Officer (H.S.C., etc., but minimum age 26) £690-£850. Women somewhat less. Appointments unestablished. F.S.S.U. benefits may be available for S.O. class. Application forms from M.L.N.S., Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D296/54A. Closing date 13th July 1954. W 2180

ENGINEER TECHNICIANS for Radiotherapeutic Institute in course of erection at the Western General Hospital, Edinburgh, 4, which will contain one 4 MeV Linear Accelerator and eight other X-Ray therapy units, to assist in problems related to the maintenance, adjustment and operation of equipment used in the treatment of patients. Chief Engineer Technician — Salary scale £630 × £20 — £750 per annum. Senior Engineer Technician.— Salary Scale £540 × £20 (3) × £25 (1) — £625 per annum. Assistant Engineer Technician.— Salary Scale £450 × £15 (3) × £20 (1) — £515 per annum. Conditions of service as recommended by the Whitley Council for Health Services (P.T.B. Circular No. 28). The posts are superannuable. Preference will be given to candidates who hold an appropriate Degree or equivalent qualifications. Placing on the scale will be according to experience. Previous experience with X-ray and/or high voltage equipment essential. The Chief Engineer must be experienced in electrical and mechanical engineering. The Senior Engineer will require to have a good knowledge of electronics. Applications, giving qualifications and experience, with the names and addresses of three referees, to be submitted immediately to the Medical Superintendent at the Hospital. W 2225

MINISTRY OF SUPPLY requires Radio/Radar Technicians at Medmenham, Bucks, and Watton, Norfolk, to prepare schedules of radio/radar equipment and breakdown into assemblies and sub-assemblies and components. Qualifications: British of British parents. Recognised apprenticeship or equivalent. Appropriate experience. Able interpret drawings, circuit diagrams and specs. essential. O.N.C. or equivalent and practical experience RAF equipments desirable. Salary: Within £480 (age 26) — £597 p.a. Not established but opportunities to compete for establishment may arise. Apply nearest Employment Exchange quoting Order No. Westminister 2852. W 2184

MINISTRY OF SUPPLY requires Engineer at Bickley, Kent, for technical control of valve inspection. Qualifications: British of British parents. Recognised engineering apprenticeship or equivalent training in Electronics. A.M.I.C.E. or M.E. or E.E. or exempting qualifications. Wide experience of Production, testing, inspection of all types electronic valves. Salary: Within £1,000-£1,320. Not established but opportunities to compete for establishment may arise. Application forms from M.L.N.S., T. and S.R., 26/28 King Street, London, S.W.1, quoting D. 259/54-A. W 2191

RESEARCH APPOINTMENTS in laboratories in Cambridge are vacant in the fields of electron microscopy and diffraction, including latest techniques of reflection electron microscopy, for research and development in problems of solid state and surface physics, metallurgy and surface chemistry. Salary according to qualifications and experience. £400-£800 p.a. Box No. W2213.

SENIOR LABORATORY TECHNICIAN (RADIO) required at South East London Technical College, Lewisham Way, S.E.4. Forty-four hour week. Salary scale £393. 15s. to £493. 15s., and with certain qualifications to £568. 15s. Further particulars and application forms (returnable within 14 days) from Secretary (782). W 2245

TECHNICIAN AND JUNIOR TECHNICIAN required for construction of prototype electromechanical apparatus in Department of Medical Electronics. Salary according to M.L.T. scales. Apply: Personnel Officer, St. Thomas' Hospital, London, S.E.1. W 2249

THE QUEEN'S UNIVERSITY OF BELFAST. Senior Technician (Electronics). Required for the Department of Chemistry, a Senior Technician with wide experience in constructing electronic apparatus. Salary scale: — £485 × £21 — £548 × £22 — £570 per annum. Applicants possessing exceptional qualifications may, on first appointment, be recommended for admission to any point on the scale. In addition, there is a possibility of promotion to a higher grade. Letters of application stating age, education and experience, together with two testimonials, should reach the undersigned by 27th June. G. E. Cowie, M.A., LL.B., Secretary. W 2217

THE ROYAL TECHNICAL COLLEGE, Glasgow, (Affiliated to the University of Glasgow.) Department of Electrical Engineering. Lecturer in Electronics: Applications are invited for a lectureship in electronics. Salary scale £600 — £50 — £1,150. Candidates should possess a good Honours Degree in Electrical Engineering, and have some experience in Servomechanisms. The duties will include undergraduate and postgraduate teaching and research. Forms of application may be obtained from the Secretary. W 2169

UNIVERSITY OF GLASGOW. Lectureship in Electrical Engineering. Applications are invited for a Lectureship in Electrical Engineering. Salary Scale: £500 × £50 — £1,100. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits. Teaching experience essential. Special knowledge of theory and operation of electrical machinery required. Applications (five copies) including the names of three referees, should be lodged not later than 30th June, 1954, with the undersigned, from whom further particulars may be obtained. Robt. T. Hutcheson, Secretary of University Court. W 2211

WIRELESS STATION SUPERINTENDENT required by the Nigeria Government Posts and Telegraphs Department for one tour of 18 to 24 months in the first instance. Option of appointment (a) on temporary terms, with salary, etc., in scale £864 rising to £1,392 a year and gratuity of up to £150 a year, or (b) with prospect of pensionable employment with salary, etc., in scale £750 rising to £1,175 a year. Outfit allowance £60. Free passages for officer and wife. Assistance towards cost of children's passages or grant of up to £150 annually for their maintenance in U.K. Liberal leave on full salary. Candidates must have had wide practical experience of modern radio techniques and equipment, in particular V.H.F.

equipment, and preferably also V.H.F. multi-channel equipment. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters. Full qualifications and experience and quote M2C/30086/EK. W 2181

WIRELESS STATION SUPERINTENDENT required by the Gold Coast Government Posts and Telecommunications Department for two tours of 18 to 24 months in the first instance. Salary, etc., according to qualifications and experience in consolidated scale £990 rising to £1,230 a year with gratuity of up to £150 a year. Outfit allowance £60. Liberal leave on full salary. Free passages. Candidates should possess a Higher National Certificate or equivalent, and have practical experience in two or more of the following fields: — V.H.F. link systems; H.F. communication network; Frequency shift keying and teleprinter maintenance; V.H.F. and H.F. Direction finding systems; Aeronautical navigation aids (ground); Manufacturing of light engineering equipment. Candidates from the British Post Office should apply through departmental channels. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/29100/EK. W 2182

SITUATIONS VACANT

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 *inclusive or a woman aged* 18-59 *inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order,* 1952.

A **FIRST-CLASS** opportunity exists in the London area for Development Engineer familiar with the design and production of miniature or telephone type relays or similar electro magnetic devices. Excellent laboratory facilities are available and the successful candidate will be required to initiate new development projects and carry them through to production. The initial salary will be in accordance with qualifications and generous advancement is possible for a man of initiative. Send details of qualifications and experience to Box No. W.2234.

A **LARGE** and well-established engineering company situated in the East London area require tool designers and draughtsmen. Applicants should have had tool room apprenticeship or equivalent, followed by experience on first-class tool design work in the light mechanical and electrical fields. Applications are invited from men of sufficient experience and ability to justify very good salaries. Excellent working conditions and staff pension scheme in operation. Please write, in confidence, giving details of experience to Box No. W 2237.

AN EXPANDING engineering programme has caused vacancies for Development Engineers experienced in one or more of the following fields: (a) Tuning mechanisms and associated V.H.F. circuits. (b) Switches for radio and low-power electrical apparatus. (c) Variable capacitors. A detailed knowledge of the material problems encountered in this type of development will be advantageous. The salary and future prospects are good, and the laboratory is situated in the London area. Please reply, giving full details of qualifications and experience, to Box No. W 2240.

AN ELECTRONIC ENGINEER, possessing an Academic or Industrial Degree and having at least five years practical experience is required for development work on a wide range of electronic instrumentation. The position offers ample scope for advancement in a rapidly expanding department. Applicants should be 25 to 35 years of age, and should write giving full details to Box No. W 1030.

AN OPPORTUNITY for young, versatile and ingenious electronic engineers to gain experience in the application of Transistors to a wide variety of circuits is offered by The English Electric Co., Ltd., Luton. Interviews may be arranged locally to suit applicants own convenience. Write with full details to Dept. C.P.S., 336/7 Strand, W.C.2, quoting Ref. 1325. W 2194

AN OUTSTANDING OPPORTUNITY is offered to an Electronics Liaison Engineer in the New Electronic Equipment Division of an old established electrical company who are expanding to a South Coast area. The qualifications for this post are a sound technical background, considerable knowledge and experience of centimetric radar systems, pulse and microwave techniques. Applicants should also be capable of co-ordinating the work of design and production authorities, and be able to accept the responsibility for assessing test equipment and specification requirements for Radar production projects. The salary for this post will be commensurate with ability. Interested applicants should write giving full details of the above experiences and age to Box No. W 2093.

A **NUMBER** of posts are vacant for men and women, in the research laboratories of Ericsson Telephones Limited, for Physicists, Physical Chemists and Electrical Engineers for work on audio frequencies, electronic switching, nucleonic equipment, semi-conductors and valves. Write giving particulars of qualifications and experience to Personnel Officer, Ericsson Telephones Limited, Beeston, Nottingham. W 2174

APPLICATIONS are invited from Engineers and Draughtsmen as shown hereunder: (a) Design Engineers and Draughtsman with experience of design of television, Services communication equipment and/or aircraft accessories. (b) Tool design Draughtsmen with experience of small to medium class press tools, jigs and fixtures. The vacancies which call for men of sound technical ability, offer good progressive positions. A good salary will be paid to the selected applicants and will be commensurate with previous experience. Applications should be addressed, in the first instance, for the attention of the Personnel Manager, The Plessey Company Limited, Vicarage Lane, Ilford. W 2239

ARMSTRONG SIDDELEY MOTORS require Electrical Engineer/Draughtsman — Higher National Certificate standard. Work is in connexion with Research Development and Production Testing Equipment for gas turbine engines. Applicants should preferably have experience in general lighting, heating, power installations, instrumentation, electronics and some mechanical experience. Apply to Reference TPEL, Personnel Manager, Armstrong Siddeley Motors, Coventry. W 2171

ASSISTANT ENGINEERS required in an Electrical Laboratory in West Surrey. Preference will be given to those holding a Degree or H.N.C., with experience in design and development of electrical relays for aircraft and other uses. Apply in writing to the Chief Development Engineer, Waymouth Gauges and Instruments Ltd., Station Road, Godalming, Surrey. W 2168

A **VACANCY** exists in the Instrument Section for an Engineer to develop improved methods of instrumentation for the flight testing of Gas Turbine Aero Engines. Some knowledge of electronics is desirable though not essential. Apply to Reference TGD, Personnel Manager, Armstrong Siddeley Motors, Coventry. W. 2201

A **VACANCY** occurs for a Development Engineer in a design group concerned with a wide range of small transformers and inductors of types used in radio equipment and electrical appliances. Preference will be given to applicants having experience of this class of work, but young engineers with a sound basic training and limited experience will be considered, and if successful will have the opportunity of gaining practical knowledge of design problems met in fulfilling commercial and military specifications. An attractive salary is offered together with good future prospects. The company's extensive laboratory and production facilities are situated in the London area. Please reply, giving full details of qualifications and experience to Box No. W 2235.

A **VACANCY** occurs with a leading manufacturer for a man experienced in Wave guide measurement. An ex-Serviceman with the necessary experience of Testing and Fault Finding on Radar Gear would be considered. Write, stating age, experience and salary required to Box No. W 2136.

A **YOUNG TECHNICAL ASSISTANT** with H.N.C. in Applied Physics or Electrical Engineering and electronics experience is required for work in the High Voltage Research Laboratories. Write, giving full details to the Personnel Officer, Research Laboratory, Associated Electrical Industries Ltd., Aldermaston Court, Aldermaston, Berks. W 2165

BRITISH TELECOMMUNICATIONS RESEARCH LTD., a Company associated with the Automatic Telephone & Electric Co., Ltd., and British Insulated Callender's Cables Ltd., has a vacancy for a senior engineer for work on the development of specialized test equipment for telecommunication systems. There is a superannuation scheme and the Company works a five-day week. Application should be made to the Director of Research, British Telecommunications Research Ltd., Taplow Court, Taplow, Bucks, giving age and full details of education, qualifications, experience and approximate salary required. W 2096

BRITISH TELECOMMUNICATIONS RESEARCH LTD., a Company associated with the Automatic Telephone & Electric Co., Ltd., and British Insulated Callender's Cables Ltd., have a vacancy for an engineer with experience of V.H.F. and S.H.F. aerial design or propagation studies, for research work connected with the development of communication systems. Vacancies also exist for engineers with experience of microwave components and circuits and/or broad-band transmission equipment. Salary according to qualifications and experience. There is a superannuation scheme and the company works a five-day week. Applications should be made to the Executive Director, British Telecommunications Research Ltd., Taplow Court, Taplow, Bucks, giving age and full details of education, qualifications and experience. W 2216

BUSH RADIO LTD., have a number of vacancies in their expanding laboratories at London and Plymouth. Applicants for posts (a) and (b) should preferably hold a B.Sc. or equivalent qualification in Physics or Engineering. (a) Research and Development Engineers and Junior Development Engineers for work in new television and circuit fields. Applicants should have interests and preferably experience in:—Telecommunications, television, network analysis, feedback, pulse techniques, optics. (b) Junior Development Engineers for interesting work on Government contracts. Experience in any of the following fields would be an advantage:—Video amplifiers, feedback, pulse techniques, microwave techniques. (c)

CLASSIFIED ANNOUNCEMENTS
continued on page 4

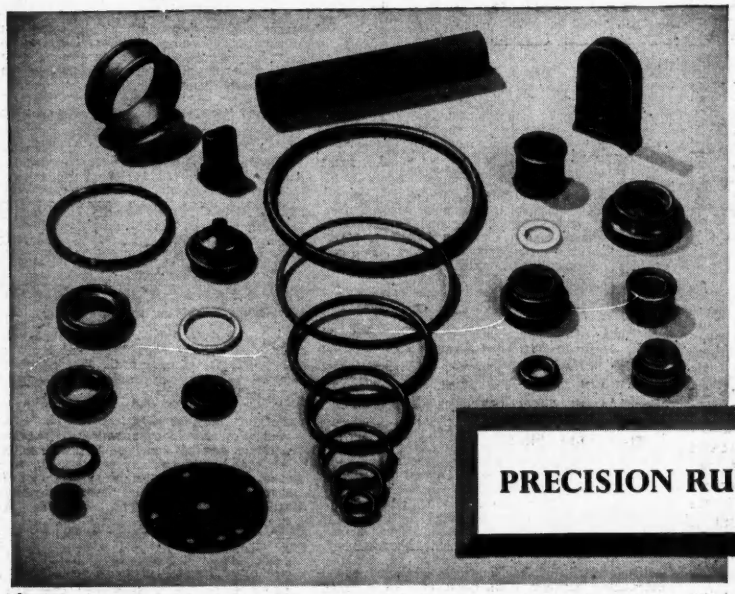
the smallest single stage axial flow fan ever produced for electronic cooling and allied applications

PLANNAIR
REGISTERED TRADE MARK

Type 2 PL 81 (2¾" diameter)
OUTPUT : 44 CUBIC FEET OF AIR PER MINUTE AT 0.25" S.W.G.
MOTOR 24/28 VOLTS D.C.

Full details and specifications of all axial flow models from:—

PLANNAIR LTD. Windfield House, Epsom Road, Leatherhead, Surrey. *Telephone : Leatherhead 3013.*



*Specialists in Rubber and Synthetic Rubber Mouldings for Industry...

PRECISION RUBBERS LTD.

Manufacturers of Rubber Parts for ROLLS-ROYCE LTD

*Prototypes to Bulk Production

PRECISION RUBBERS LTD · BAGWORTH · LEICESTERSHIRE Telephone : BAGWORTH 241/2

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

Development Engineers to initiate design and engineering layout of domestic radio receivers. Experience of design of domestic radio receivers, and familiarity with working with drawing office and production departments, are required. Good prospects, pension scheme. Interviews in London or Plymouth. Write giving full details and salary required to the Chief Engineer, Bush Radio Ltd., Power Road, Chiswick, W.4. W 2229

CHIEF ENGINEER required by well known electronic instrument manufacturer, W. of London. Highest technical qualifications plus executive ability essential. Must be able to lead team of development workers over wide electronic and magnetic field, and advise Board on all technical problems. Sound prospects with steadily expanding Company. Pension scheme. State full details to Box GA 039, 4 Salisbury Court, Fleet Street, London, E.C.4. W 2198

CHIEF INSPECTOR required for modern and progressive electronic component manufacturers. Must be a first class organiser, and be A.I.D. approved, experience of a similar capacity advantageous. Salary will be according to qualifications and the prospects are unusually good. Apply Box No. 1063.

DECCA RADAR LIMITED require Assistant Electrical Engineers. Interesting vacancies are open with an active and expanding development group on the design of small mechanisms, servos and power supplies associated with radar equipment. The work is interesting and varied. Age limits 24-32 years. Previous experience in the above work and applied mathematics would be an advantage. Good salary offered depending on age and experience. Applicants with suitable qualifications should apply to the Chief Development Engineer, Decca Radar Limited, 9 Davis Road, Tolworth, Surrey. W 1998

DECCA RADAR LIMITED require Technical Electronic Inspectors for permanent and progressive staff posts. Wide practical experience in a similar field is desirable, backed by a sound technical training. Apply to the Personnel Officer, Decca Radar Ltd., 2 Tolworth Rise, Tolworth, Surrey. W 1051

DESIGNER DRAUGHTSMAN required for Electronics Drawing Office. Higher National Certificate or experience with electronic equipment and Ministry procedure essential. Applications which should include full details of qualifications, experience and salary required, should be forwarded to Personnel Department (E.D.O.), Murphy Radio Ltd., Welwyn Garden City. W 2204

DEVELOPMENT ENGINEERS. Several vacancies exist for engineers to deal with the design of control and measuring equipment for a wide variety of applications. This work is mainly concerned with the use of magnetic amplifiers; applicants need not have had specific experience of magnetic amplifiers but must be keen to make a study of their design and application. Applicants should either have or be studying for H.N.C. or equivalent. App'y Personnel Manager, Elliott Bros. (London) Ltd., Airport Works, Rochester, Kent. W 2110

DEVELOPMENT ENGINEER. Opportunity for qualified man (Degree or equivalent) with design experience of modern electronic circuitry, including telecommunication. A small progressive company on South coast offers senior post to engineer of proved ability. A good organiser capable of taking design to production stage essential. Write stating age, training and experience to Box No. W 198.

DEVELOPMENT ENGINEER required for work on radio and T.V. Test Equipment. Interesting work offering wide scope. Permanent. Pension Scheme. State full details of qualifications, experience, etc., to Chief Engineer, Taylor Electrical Instruments Ltd., Montrose Avenue, Slough. W 1067

DEVELOPMENT ENGINEERS required for Research and Development work on Cold-Cathode Tubes. Applicants should preferably have had experience in the Valve or Lamp industry, or on closely related work. A Science Degree, Engineering Degree, or a similar qualification would be helpful. An attractive salary is offered in accordance with experience, ability and qualifications. Please write, giving details to the Personnel Officer, Ericsson Telephones Limited, Beeston, Nottingham. (Reference LK/3.). W 2206

DRAUGHTSMAN experienced in the radio field on Electrical/Mechanical Assemblies required for interesting work on aircraft. Write giving full particulars including age and salary required to Personnel Department, Vickers-Armstrongs Ltd., Hursley Park, Nr. Winchester. W 2232

DRAUGHTSMEN. Vacancies for senior Draughtsmen with experience of Electronic and/or Electro mechanical engineering required, preferably with experience of Ministry requirements. Excellent prospects with good commencing salaries; non-contributory Pension Scheme in operation. Applications will be treated in strict confidence and should give full chronological details of qualifications, experience and age to John A. Smith, Ltd., 24 Lichfield Street, Wolverhampton. W 1043

E. K. COLE LIMITED (Malmesbury Division). The Malmesbury Division of E. K. Cole Ltd., is engaged in the development and production of radar and communication equipment associated with high priority defence projects. Vacancies exist in the Development Department for Project Engineers, Engineers and Assistant Engineers with training and experience in the following fields:—Pulse circuits—Pulse Modulators, Strobe Systems, Video Amplifiers, Time Base Generators, etc. Microwave techniques—Aerial design for radar scanners and waveguide components for high power T/R Units.—H.F. and V.H.F. Communication, Airborne and ground receivers, transmitters and Aerial Systems. — Transformer design, High frequency power transformers for airborne equipment.—Mechanical Engineering, Light mechanisms and structures for radar scanners. Applicants should have had technical training to Degree or Higher National Certificate standard, and in the case of Project Engineers and Engineers appropriate technical design experience is necessary. Commencing salaries will be dependent on qualifications and experience, and will compare favourably with scales prevailing in the radio industry. Housing accommodation may be available in the near future for successful married applicants. A superannuation scheme is in operation, together with canteen and full welfare facilities. Applicants should apply in the first instance for a technical staff application form to Personnel Manager, E. K. Cole Ltd., Malmesbury, Wilts. W 2058

ELECTRONIC DRAUGHTSMEN with good experience in layout work are required by the Nelson Research Laboratories, Stafford, for work on prototype equipment. This post offers scope for advancement to men of initiative. Only men with experience will be considered. Reply quoting Ref. 1243A to Dept., C.P.S., 336/7 Strand, W.C.2. W 2162

ELECTRONIC ENGINEER (about 30 years) required by Scientific Instruments Makers for servicing photo-electric instruments. Good prospects for keen man. Camden Town district. Five-day week, superannuation, good welfare facilities. Please apply, stating age, experience and salary required, to Box No. W 2123.

ELECTRONIC ENGINEER for Research Laboratory. Senior position for engineer with experience of research and design of special circuits at medium to low frequencies. Knowledge of Physics an advantage. Qualifications should include a good Degree and preferably five years' experience in similar post. Interesting and rewarding work with excellent prospects for advancement. (Ref. 73). Senior Engineer for work in modern research laboratory on problems of high speed switching, gas tube circuits and general pulse methods. Problems call for advanced techniques, good Degree or equivalent in Electronic Engineering with not less than three years' experience required. (Ref. 74). Senior Servo-Mechanism Engineer for research work on complicated instrument type servo. Work involves analysis of present systems and design of new types. Experience of general electronics, gyro-mechanisms and analogue computers an advantage. This post calls for a man with excellent qualifications and at least three years' experience on similar problems. (Ref. 75.) Write in detail, quoting reference No. of position sought to: The Personnel Dept. (Technical Employment), De Havilland Propellers Limited, Hatfield, Herts. W 2088

ELECTRONIC ENGINEER. preferably graduate of recognized training establishment, required for design and maintenance of Industrial Electronic Control and testing equipment of all types. Salary according to qualifications and experience. Location Midlands Enginering Plant. Apply Box No. W 1021.

ELECTRONIC ENGINEER/PHYSICIST, aged 26-35 required for appointment to staff of London Company to take charge of Inspection of electronic and nucleonic apparatus. Previous similar experience essential. Write full but brief details of experience, education, etc., to Box No. W.2086.

ELECTRONIC ENGINEER required for a Senior post to build up and control an entirely new group working on advanced valve applications. This is an opportunity for a man of initiative, imagination and energy. Applicant should have a sound working knowledge of modern circuit techniques in the Electronic field particularly with application to radio and television and should hold a Degree or equivalent. Essential qualities are an aptitude for original experimental work and an ability to guide the work of others. Salary will be commensurate with responsibility. Apply in writing to Personnel Department, M.O. Valve Co., Brook Green, Hammersmith, stating age, qualifications and details of experience, quoting Ref. A.A. W 1011

ELECTRONIC ENGINEER required by E.M.I. Research Laboratories Ltd., for responsible work on special problems in connexion with Television Receivers. Some knowledge of theory is expected, and practical experience with receivers is desirable. Applicants should not be liable for National Service. Apply, stating full particulars, to the Personnel Dept., Electric & Musical Industries Ltd., Blyth Road, Hayes, Middlesex. W 2106

ELECTRONIC ENGINEER required by capacitor manufacturer for development work on test instruments and electrical research. Opportunity for young engineer with some years' experience in test gear design. London area. Write Box No. W 1066.

ELECTRONICS ENGINEER required to take charge of a group developing instrumentation for a large transonic tunnel. Candidates should have a sound theoretical and practical knowledge of general electronic work and will be required to develop circuits connected with the automatic recording of data from strain-gauge balances and electronic computors for working out results. Applications should be made to The Chief Executive, Aircraft Research Association Ltd., 33 Midland Road, Bedford, stating age, qualifications and experience. W 1062

ELECTRONIC ENGINEERS, aged 23 upwards, having H.N.C. or equivalent qualification, required by Electronic Instruments, Ltd., Richmond, Surrey. Written applications only in first instance. W 199

ELECTRONIC ENGINEERS required by The General Electric Co., Limited, Brown's Lane, Allesley, Coventry, in their Development Laboratories for work on the following items:—(a) Application and circuit theory of Transistors. (b) Design of R.F. modulators. (c) Investigation into valve parameters. (d) Design of valve test apparatus associated with (c) above. (e) Trials team in connexion with Guided Weapons. (f) Development of Pulse Circuitry Techniques for Guided Weapons. (g) Servo-Mechanisms. (h) Microwave Development. (i) Test equipment. (j) General radar circuit development. (k) Power units including Electronic Stabilizers and Rectifier systems. (l) Magnetic amplifiers. Applicants preferably with a Degree or an equivalent qualification should have had at least two years' experience in the development and engineering of Service equipment as well as experience in one of the above. Reply stating age, qualifications and experience to the Personnel Manager, Ref. R.G. W 2183

ELECTRONIC ENGINEERS to work within our trials division at Edinburgh. The nature of the work involves conducting trials and evaluating the performance of fire control; navigational and landing systems under development. Applicants should possess a Physics Degree or considerable recent practical experience in this field. Good opportunity in expanding department. Staff Pension

CLASSIFIED ANNOUNCEMENTS
continued on page 6

EKCO Type N529 Scaler
for all low-activity counting

Ekco Type N529 is a five decade Scaler using ' Dekatron ' tubes. It incorporates a stabilized high-voltage supply, an input amplifier and a pulse height discriminator. H.T. and L.T. supplies are available for operating a Geiger-Muller Probe or Scintillation Counter and it requires only the addition of a suitable radiation counter to form a complete counting equipment. The setting-up controls are situated behind a hinged door and routine operation is by means of press-button switches.

BRIEF SPECIFICATION

INPUT RESOLUTION
250 Microseconds

INPUT SENSITIVITY
Positive: 5 volts min. to Direct or Probe input.
Negative: 0.1 volt min. to G.M. input.

AMPLITUDE DISCRIMINATOR
Only pulses exceeding a pre-set amplitude are counted, the acceptance level being set by a potentiometer calibrated from 5-50 volts.

TEST FACILITY
A mains frequency check is included

H.V. SUPPLY
The output voltage is variable over two ranges, 250-1,000 and 500-2,000 volts, shown by the built-in meter

MAINS INPUT
110-120 volts and 200-250 volts; 40-60 c/s.

SIZE
20¾" x 11¾" x 12¾"

EKCO *electronics*

Write for the complete catalogue of Ekco Nucleonic and Electronic Equipment, including Scintillation Counters, Scaling Units, Counting Ratemeters, Radiation Monitors, Vibrating Reed Electrometers, Geiger Muller Tubes, Lead Shielding, Linear Amplifiers, Power Units, Complete Counting Installations, Thickness Gauges.

Sales, Installation and Service :—

EKCO ELECTRONICS LTD • EKCO WORKS • SOUTHEND-ON-SEA • ESSEX

SITUATIONS VACANT (Cont'd.)

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

Scheme. Apply quoting Ref. EE/TID and giving full details of qualifications and experience to the Personnel Officer, Ferranti Limited, Ferry Road, Edinburgh. W 2108

ELECTRONIC INSTALLATION and Service Engineer required for work in field and laboratory. Interesting and responsible post in new expanding department. Duties embrace V.H.F. Electronic and Nucleonic activities in commercial sphere. Applicants must have practical technical knowledge and servicing experience, preferably with electronic instruments. Write, stating age, qualifications and experience, to Personnel Manager, E. K. Cole Ltd., Southend-on-Sea. W 2161

ELECTRONICS OR ELECTRICAL ENGINEER required for senior post in development laboratory of capacitor manufacturer. Excellent scope for man under 35 with experience in capacitor, insulation or cable industry. Works, East London. Write Box No. W 1060.

ELECTRO-MECHANICAL ENGINEER required, preferably over 30 years of age, fully qualified with experience of magnetic amplifiers, servo mechanisms and speed control of rotating aerial systems. Must be conversant with modern light alloy techniques, strength of materials and static and dynamic balancing problems. Write in confidence giving full particulars to Personnel Manager, Standard Telephones and Cables Ltd., Oakleigh Road, New Southgate. W 2158

ENGINEER, experience of mechanical design of subminiature electronic equipment. Applications should be familiar with layout and wiring to interservice standards, design and manufacture of mechanical parts and preparation of working drawings. Degree not essential, preference given to persons with good practical experience. (Ref. 86). Please write in detail quoting reference number of position sought, to: The Personnel Manager (Technical Employment), De Havilland Propellers Limited, Manor Road, Hatfield, Herts. W 2127

ENGINEERS who wish to broaden or commence career as electronic engineers in a field of great interest and variety and involving latest techniques can avoid restrictive specialization by joining Marconi Instruments, who produce light current communications, measuring and test apparatus for a wide range of requirements. We have positions for men of Degree standard and experience, also City and Guilds Telecommunications Certificate standard, or compensating experience and natural aptitude for electronic engineering. Holiday arrangements if fixed can be held. Saturday interview, if required. Applications in strictest confidence. Apply Marconi Instruments Ltd., Longacres, Hatfield Road, St. Albans. W 2228

E.M.I. RESEARCH LABORATORIES LTD., invite applications from Engineers with audio design experience, for posts involving interesting and varied work in the audio-video field. Applicants should have a University Degree in engineering or physics or equivalent professional qualifications. Please write full details to the Personnel Department (RL/7), E.M.I. Ltd., Hayes, Middlesex. W 2188

ERICSSON TELEPHONES LTD., have in their Research Laboratories a number of vacancies for circuit designers and equipment engineers to work on nucleonic instruments, and interesting new developments in electronic computing and switching; both senior and junior posts are available. Applicants should have a degree or equivalent plus several years' experience of appropriate work for the senior posts; correspondingly reduced qualifications and experience will be accepted for junior posts. Salaries will be in accordance with age, qualifications and experience. Applications, giving details of age, academic or other training and qualifications, experience, and starting salary required, should be sent to the Personnel Officer, Ericsson Telephones Ltd., Beeston, Nottingham. W 197

EXPERIENCED Radio Testers and Inspectors required for production of communication and radio apparatus. Also Instrument makers, wirers and assemblers for Factory Test apparatus. Apply Personnel Manager, E. K. Cole Ltd., Ekco Works, Malmesbury, Wilts. W 146

EX-SERVICE RADIO-RADAR MECHANICS. A leading company in the Electronic Field has vacancies for men interested in manufacture and maintenance of radar equipment. Opportunities occur in the factory and in the outside maintenance field for men who have had Service training and some theoretical knowledge. Applicants should write giving full details of their experience, etc. to Box No. W 2135.

FAULT FINDERS AND TESTERS. A large Electronic Engineering Company invite applications from Fault Finders possessing a good technical background of V.H.F. Transmitter Receivers employing Frequency Control, Automatic Modulation, A.G.C. Automatic Frequency systems. Knowledge of M.O.S. inspection procedure and requirements an advantage. Rates of pay ranging from 4s. 2d. to 4s. 11d. per hour according to qualifications and experience. Applications are also invited from Skilled Electronic Wireman and Electro-Mechanical Instrument Makers. East London area. Please reply, giving full details of experience to Box No. W 2167.

FERRANTI LIMITED, Dundee, have a staff vacancy for an Assistant Test Supervisor to control a department engaged in testing microwave devices Qualifications for this vacancy include a Degree in electrical engineering or equivalent. Previous experience in this type of work is an advantage but is not essential. Apply in confidence to Personnel Supervisor, Ferranti Ltd., King's Cross Road, Dundee. W 2170

FERRANTI LTD. (MOSTON), MANCHESTER, have the following vacancies in their Valve Engineering Laboratory:—(1) Electronic Engineers possessing Degrees in Physics or Electrical Engineering with vacuum physics or electronics as a subject. Previous experience of valve development is not essential. Applications would also be considered from candidates holding H.N.C. in Applied Physics. Reference SWM. (2) Graduate Engineer possessing experience of circuitry technique to be responsible for the work of an "applications" section of the laboratory dealing with industrial valves. The duties of this engineer would include liaison with valve designers at all stages of the development of new valves, the devising of new applications of existing types and technical liaison with customers and potential customers. Ref. IVS. Permanent staff appointments with pension benefits. Application forms from Mr. R. J. Hebbert, Staff Manager, Ferranti Ltd., Hollinwood, Lancs. Please quote appropriate reference. W 2175

GUIDED WEAPONS. A vacancy exists for an experienced Engineer to take charge of a group engaged on the development of missile control systems and associated simulators. Applications with the names of two referees should be made to: Employment Manager, Vickers-Armstrongs Limited, Weybridge Works, Weybridge, Surrey. W 2073

GUIDED WEAPONS. Senior Electro-Mechanical Designer is required for work connected with Guided Weapon Development. Applicants should have suitable experience, with H.N.C. or higher qualifications, and be capable of controlling a design group. Applications, with names of two referees, should be made to: Employment Manager, Vickers-Armstrongs Limited, Weybridge Works, Weybridge, Surrey. W 2074

GYROSCOPES AND SIMILAR PRECISION DEVICES. An interesting vacancy has arisen for a Senior Engineer to take charge of and build up a development section in this field with The English Electric Co., Ltd., Luton. Essential requirements are experience in the design and engineering of precision mechanical equipment. Engineers interested are invited to write to Ref. 1326, Dept. C.P.S., 336/7 Strand, W.C.2, for an appointment either in their locality or in London, whichever is preferred. W 2195

INSTALLATIONS DRAUGHTSMAN. An opportunity occurs for a young, fully experienced Draughtsman to undertake the design of Experimental Radio and Electronic installations in modern aircraft of various types. Stressman. A similar vacancy occurs for a Stressman to work on the same and associated projects. This is an excellent opportunity for men with experience in this field to join a small expanding drawing office in an established company in Buckinghamshire. Write: Giving full particulars of age, qualifications and experience to: Airtech Limited, Aylesbury and Thame Airport, Haddenham, Bucks. W 1061

INTERESTING WORK in connection with the development of loudspeakers of conventional and novel types is offered by a large manufacturing company in the London area. A sound basic knowledge of electro-acoustic problems is the primary requirement, and some knowledge of amplifiers and other electronic apparatus will be of value. Write giving full personal particulars to Box No. W 2233.

JUNIOR DEVELOPMENT ENGINEERS are urgently required to assist in the development of precision electronic laboratory instruments. Successful applicants will be engaged on interesting long-term projects concerned with the development of a wide range of equipment. The appointments are permanent and carry considerable technical responsibility. Applicants should have had previous development experience preferably in the instrument field. Academic qualifications ranging from O.N.C. to Degree standard are acceptable. Salaries are dependant upon age, qualifications and experience. Apply stating full details to the Chief Engineer, Messrs. Furzehill Laboratories Ltd., Shenley Road, Boreham Wood, Herts. W 195

JUNIOR DRAUGHTSMEN required. Excellent opportunity for suitable men with at least Ordinary National Certificate, to broaden experience and develop progressive career with prominent well established organization. Near City centre and all amenities. Easy reach London. Well served transport routes. Holidays fixed can be held. Apply Marconi Instruments Ltd., Longacres, Hatfield Road, St. Albans. W 2227

JUNIOR PLANNING ENGINEER. Opportunity occurs for a young planning engineer (Engineering Degree or H.N.C. standard). The selected candidate will receive training for a senior post in the coilwinding production engineering department of a large and well-established company situated in the Eastern suburbs of London. An adequate commencing salary will be paid for this position. Please reply, giving full details to Box No. W 2177.

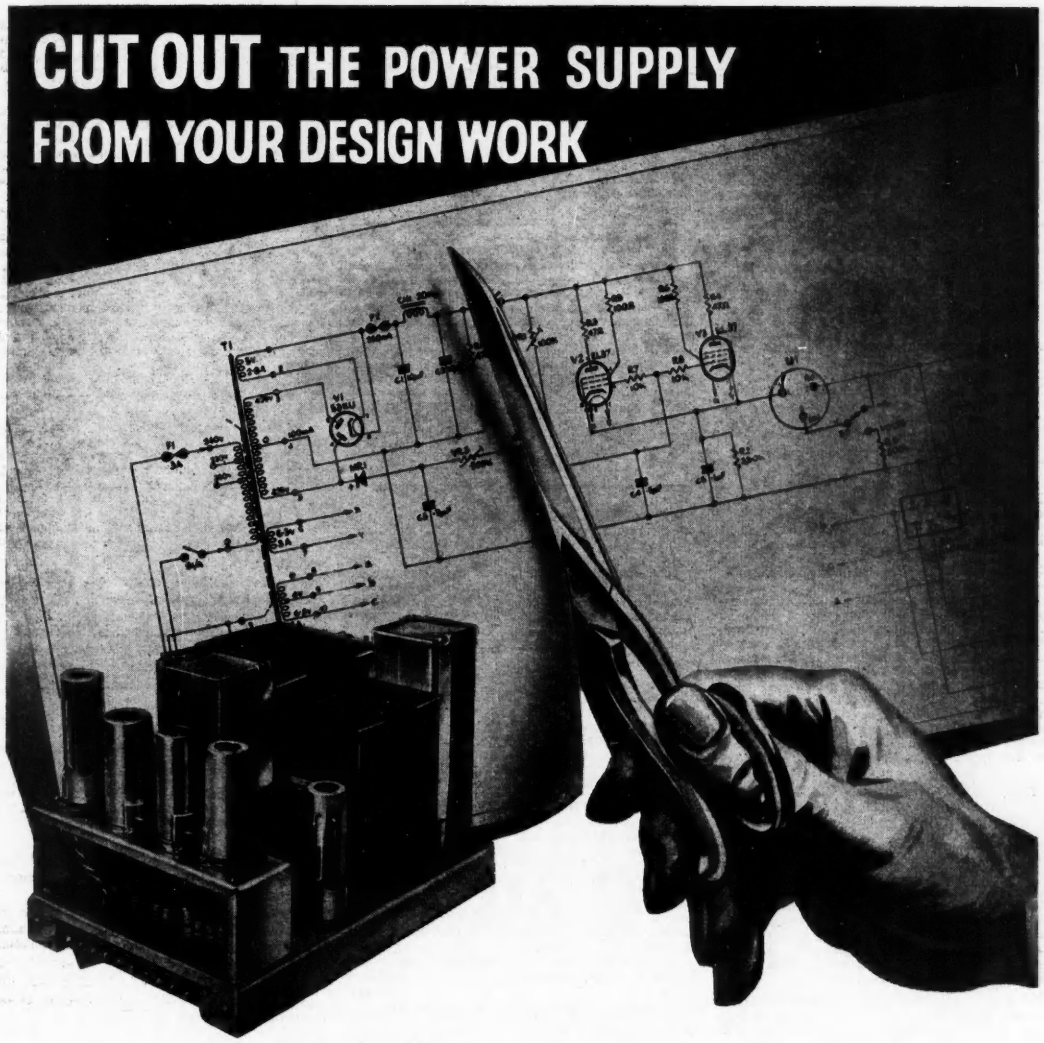
JOSEPH LUCAS (GAS TURBINE EQUIPMENT) LTD., invites applications for Electronic Engineers. Some knowledge of servo mechanisms would be an advantage. Should have University Degree. These appointments are pensionable and offer good prospects to individuals with initiative and technical ability. Salary will be in accordance with experience and qualifications. Details of experience and qualifications should be sent to Personnel Manager, Joseph Lucas (Gas Turbine Equipment) Ltd., Shaftmoor Lane, Hall Green, Birmingham, 28. W 2202

LABORATORY ASSISTANT with electrical and/or chemical experience, required for research on electronic components and materials. Apply G. V. Planer Ltd., Hanworth Trading Estate, Feltham, Middlesex. FELtham 3399. W 1064

MARINE RADAR AND RADIO SERVICE ENGINEER. Applications from candidates with several years' experience in the maintenance of Marine Radar, Radio and Echo Sounder equipment will be considered for the post of resident engineer in Port Said. The post, which is for

CLASSIFIED ANNOUNCEMENTS
continued on page 8

CUT OUT THE POWER SUPPLY FROM YOUR DESIGN WORK



The Solartron Power Supply Sub-Units offer a new service to design engineers by supplying as a *component* a stabilised power supply of known characteristics, thereby rendering unnecessary the tedious and uneconomical work of designing and constructing power supplies for experimental prototype, test or short series equipments. The units may be stocked as ordinary components and returned to store after use ; their cost is little more than the cost of their component parts and thus they save both time and money.

Main features of Model SRS 154B, a typical unit in the range :

- **250 volts, 50 m/a.**
- **Stability ratio 400 : 1.**
- **Source Impedance 0.05 ohm.**
- **Ripple content less than 200 microvolts.**
- **Dimensions 6" × 9" × 6".**
- **Cost £30.**

Other models available.

SOLARTRON

LABORATORY INSTRUMENTS LTD.

Solartron Works, Queen's Road, Thames Ditton, Surrey.

Tel. : Emberbrook 5611 Cables : Solartron, Thames Ditton.

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

a minimum tour of two years, will become vacant mid-summer and the suitable applicant will be required to commence training in England as soon as possible. The post provides free accommodation, all household expenses, houseboy, medical charges and passage for engineer and family. W. H. Smith & Co., Electrical Engineers Ltd., 68 Grosvenor Street, Manchester, 1. W 1045

McMICHAEL RADIO LTD., require Senior and Junior Engineers in their equipment division laboratory at Slough. Training and experience in the field of applied electronics (including communications) and experience of working with Government Departments are the chief qualifications required. Write stating age and full details of training, qualifications and experience to the Chief Engineer, Equipment Division, McMichael Radio Ltd., Slough, Bucks. W 157

MESSRS. S. SMITH & SONS (ENGLAND) LTD., require the services in the Cheltenham area of a number of Qualified Electrical Engineers, Physicists and Mathematicians for research work in the field of small electro-mechanical systems and guided weapons. Knowledge of electronics and servo mechanisms is desirable but consideration will be given to ability, initiative and inventiveness rather than experience. Salaries will range from £500 to £1,500 per annum, according to ability and experience. Housing accommodation is guaranteed to selected applicants after a satisfactory probationary period. Where necessary arrangements can be made for applicants to take summer holidays this year. Application should be made in the first instance to the Personnel Manager, S. Smith & Sons (England) Ltd., Evesham Road, Bishops Cleeve, Nr. Cheltenham, Glos, for application form quoting Ref. GW8/F. W2207

METHODS ENGINEER An excellent opportunity occurs for a Methods Engineer in a modern organization engaged in the manufacture of small mechanical and electrical products. The position offers ample scope for a man with wide experience and who is capable of interpreting new ideas into practical application. Applications, which will be treated in strict confidence are invited from Production Engineers with a practical time and motion study background. In the London area, this vacancy is one of a permanent nature and offers a superannuation and insurance scheme. Please reply, giving full details, to Box No. W 2155.

MINISTRY OF SUPPLY requires Assistant Foreman at Bickley, Kent, to assist development, supervise manufacture of special electronic test gear. Qualifications. British of British parents. Recognised apprenticeship or equivalent training in electronics. Knowledge pulse techniques, UHF oscillators, oscillscopes, high voltage measurements. O.N.C., City and Guilds or equivalent desirable. Salary within £506 (age 26) — £629 p.a. Not established but opportunities to compete for establishment may arise. Apply any Employment Exchange quoting Order No. Westminster 2856. W 2190

MURPHY RADIO LIMITED have vacancies in the Electronics Division Laboratories for qualified Engineers to design and develop the following: 1. V.H.F. and U.H.F. Communications equipment. 2. Airborne and ground radar equipment. 3. Computing devices and servo systems. 4. Nucleonic equipments and measuring instruments. The salary range is £600-£1,100 per annum depending upon experience. Further posts are available to Engineers of H.N.C. standard or equivalent having less experience, the salary range being £450 to £650 per annum. These vacancies are at Welwyn Garden City but one or two vacancies of a similar nature are available at the Ruislip works. Applications giving age, full details of qualifications, experience and salary required should be forwarded to Personnel Department (E.D.L.), Murphy Radio Limited, Welwyn Garden City, Herts. W 2226

PHYSICIST OR ELECTRICAL ENGINEER for development work on data transmission devices, miniature motors and instrument servomechanisms. Candidates aged 22-35 should either have (a) University Degree in Physics or Electrical Engineering. (b) qualifications exempting from Grad. I.E.E. examination. Laboratory experience in light electrical engineering desirable. Written applications with full particulars to Personnel Manager, Muirhead & Co., Ltd., Beckenham, Kent. W 2160

PHYSICISTS AND ENGINEERS. Elliott Brothers (London) Limited, Guided Weapons Division, requires Physicists and Engineers for research and development work in the North London area. Applicants should possess Higher National Certificate or a Degree in Physics or Electrical Engineering. Experience in research, development and design in one or more of the following subjects is desirable but not essential. (a) Microwave aerials, waveguide components and instruments. (b) Radar circuit techniques. (c) Electro-mechanical instruments. (d) Electric and Hydraulic Servo-mechanisms. Salary will be according to qualifications and experience and senior positions are available. Applications, giving details of age, education and experience should be made to Personnel Officer, Elliott Brothers (London) Ltd., Elstree Way, Borehamwood, Herts, quoting Ref. 5206. W 2163

PLANNING ENGINEERS required. Applicants should preferably have a press tool background and have had previous experience of process planning of small electrical and mechanical assemblies. These vacancies present attractive opportunities and work of a wide and interesting nature. A good salary will be paid to the selected applicants. Eastern suburbs of London. Please reply, giving full details of qualifications and experience to Box No. W 2236.

PROGRESSIVE position of great interest to Electronic Engineers. Large Midland Engineering Plant requires qualified and experienced electronic engineers both senior and junior for rapidly expanding laboratory engaged upon measurement and control problems. State age, qualifications and experience fully in confidence to Box No. W 2208.

PYE LIMITED, Radio Works, Cambridge, invite applications for the appointment of Electrical Draughtsman capable of producing intelligent circuit and layout diagrams of radio equipment. Applications in writing to Personnel Manager. W 2223

PYE LIMITED, Radio Works, Cambridge, invite applications for appointment of Technical Author to compile maintenance handbooks on individual radio equipments. Command of English and technical background essential. Applications in writing to Personnel Manager. W 2222

PYE LIMITED require experienced Development Engineers for radio receiver development in Cambridge. Salaries in the range of £400 to £800 according to qualifications. Apply Personnel Department, Pye Ltd., St. Andrew's Road, Cambridge. W 2187

RESEARCH ENGINEERS. Outstanding opportunities exist with D. Napier & Son, Ltd., on interesting and varied work in connexion with the following:—High Speed Bearings—High Duty Gearing—Shaft Sealing against Liquids and Gases—Electro Mechanical Transducers for Transient Pressure and Temperature Measurement — Electronic Instrumentation — Vibration Measurement—Experimental Stress Analysis—General Mechanical Researches—Hydraulics—Application of statistical method to Engineering Research. Qualified engineers with specialized experience in any one or other of these subjects are invited to apply to Dept. C.P.S. 336/7 Strand, W.C.2, quoting reference SA45. W 2059

SALES ENGINEER for high class oscilloscopes and associated gear. Good knowledge of application techniques, and D.C. Amplifiers. Connexions with similar instrument market essential. Box No. W. 1046.

SCIENTIFIC INSTRUMENT MAKERS in North London have a few vacancies for skilled laboratory assistants and wire-men for the development and production of high quality electrical and electronic apparatus. Five-day week, canteen, good welfare facilities. Please apply, stating age, experience and salary required, to Box No. W 2122.

SENIOR AND JUNIOR Electronic Engineers required for Audio and Acoustic projects. Applicants should give full details of qualifications and experience by letter to Personnel Manager, Pye Ltd., St. Andrew's Road, Cambridge. W 2078

SENIOR AND JUNIOR ENGINEERS required for interesting research and development work on Servo and Electromechanical systems, by the Nelson Research Laboratories, The English Electric Co., Ltd., Stafford. The work includes both experimental and analytical approach with the aid of calculating machines where necessary. Junior engineers who have Honours Degrees and have completed an engineering apprenticeship, will be given training in this work if required. Reply to Dept. C.P.S. 336/7 Strand, W.C.2 quoting Ref. 1327. W2193

SENIOR CHECK TEST ENGINEER required by the Inspection Department of the English Electric Co., Ltd., Luton. Applicants should be of H.N.C. standard with several years' experience in one or more of the following:—Servo mechanisms, Gyros, Light Hydraulics Systems, Electronics. This position offers an attractive salary and opportunities for advancement in an expanding industry. An excellent Pension Scheme is in operation. Please reply to The Personnel Manager, English Electric Co., Ltd., The Airport, Luton, Beds, quoting Ref. 1149D. W 2173

SENIOR COILWINDING PLANNING ENGINEER required experienced in the planning of radio and television coils. The selected candidate will have the drive and initiative necessary to deal rapidly with the day-to-day electrical and mechanical problems on the shop floor. East London area. This vacancy, for which a good salary will be paid, presents ample scope and opportunity to a man of first-class ability. Please reply, giving full details of experience to Box No. W 2178.

SENIOR DESIGN DRAUGHTSMEN required by a large engineering company due to expansion of company's services and commercial business. Applicants should have a comprehensive knowledge of mass production of radio, television and electronic equipment. Salary up to £700 per annum: monthly status. The vacancies are of of a permanent and progressive nature. Company superannuation and life assurance schemes in operation. Please reply, giving details of experience to Box No. W 2179.

SENIOR PHYSICISTS AND ENGINEERS are invited to write to the Research Director of Decca Radar Ltd., regarding the opportunities which exist in this Company owing to the continual expansion of its activities in the field of navigational aids. Senior posts are on a substantial salary scale and there are excellent prospects of higher appointment for men of proven ability. British Nationality is essential. A Pension Scheme is in operation. Letters giving full personal data should be addressed to the Research Director, Decca Radar Limited, 2 Tolworth Rise, Surbiton, quoting reference RLA/28. W 2131

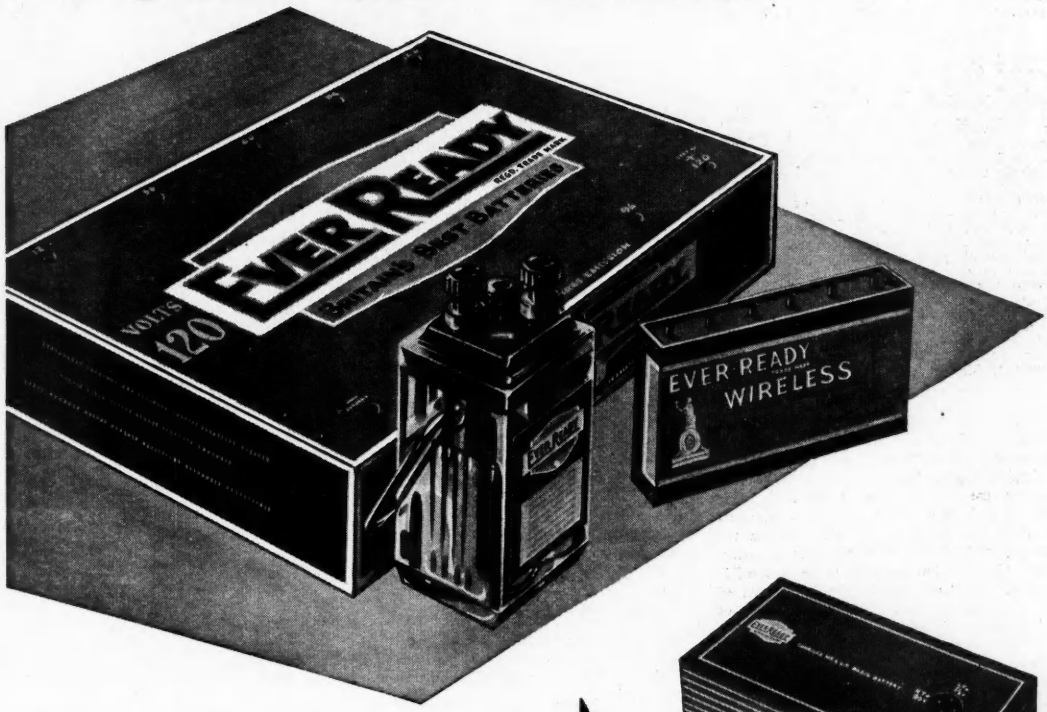
SERVICE ENGINEER: Glasgow, for Amplifiers and Recorders. Mechanical dexterity advantageous. Experience of T.V. neither necessary nor desirable. Box. No. W 1050.

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LTD., have vacancies for qualified Electronic Engineers for Flight Trials Work on Guided Missiles. Experience on electronic experimental work or Service experience on radio or radar is essential. Age limits 27-38 years. Applications giving particulars of qualifications and experience should be addressed to The Chief Engineer, Armaments Division, Sir W. G. Armstrong Whitworth Aircraft Ltd., Baginton, Coventry. W 2141

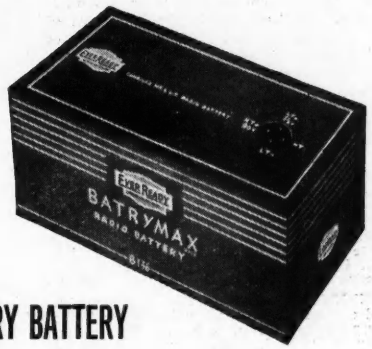
SPERRY GYROSCOPE COMPANY LIMITED invite applications from Engineers holding a Degree or membership of a professional Institution, for interesting research design and development work on aircraft instrumentation, automatic controls, marine products, and guided missiles. Vacancies include: Electro-Mechanical Engineers for

CLASSIFIED ANNOUNCEMENTS
continued on page 10

from all this



to just this



The EVER READY development that revolutionised the DRY BATTERY

The " Batrymax " dry battery is an Ever Ready development that made possible the miniature self-contained hearing aid and the smaller, lighter electronic equipment of today. In addition, Ever Ready " Batrymax " layer-cell construction gives you more efficient, more economical radio batteries. For example, the latest B136 " Batrymax " battery, used with new Ever Ready low consumption valves, has a balanced service life of over 400 hours. At the present time, you cannot better a " Batrymax "; but Ever Ready research goes on, seeking new developments to increase, still further, the efficiency of the dry battery.

EVER READY
REGD. TRADE MARK
MADE IN BRITAIN

Batrymax

"Batrymax" is a Trade Mark of The Ever Ready Co. (Gt. Britain) Ltd.

The engagement of persons answering these advertisements must be made through a Local Office of the Ministry of Labour or a Scheduled Employment Agency if the applicant is a man aged 18-64 inclusive or a woman aged 18-59 inclusive unless he or she, or the employment, is excepted from the provisions of the Notification of Vacancies Order, 1952.

Brentford and Feltham, also Mechanical Engineers for Gloucestershire. Additional to above qualifications desirable to have apprenticeship, knowledge of production methods, and experience in design of one or more of the following:—Gearing, instrument mechanisms, servos. Hydraulic Engineers for Sunbury and Feltham. Must have experience of practical design and theoretical analysis of hydraulic systems. Knowledge of high pressure hydraulics as applied to aircraft or hydraulic servo systems desirable. Electronic Engineers for Brentford and Feltham. Additional to above qualifications, practical experience and knowledge of production methods, with experience in one or more of the following is desirable; control circuits, D.C. Amplifiers, Computing devices, Video circuits. Pension Scheme. Apply giving full details, including an indication of the salary range and location preferred, to Personnel Manager, Sperry Gyroscope Co., Ltd., Great West Road, Brentford, Middlesex. W 2200

SYSTEMS ENGINEER. An attractive senior position is offered to an Engineer with wide experience in electronic and light electromechanical engineering. He must be able to combine the techniques used in both these fields with those of analogue computing, servo mechanisms and radar. He will work on the planning and development of aircraft instrument and navigation systems and be responsible for leading a team on the detailed design of the electrical and electronic components of such systems. Please apply, giving particulars of qualifications and experience to Personnel Officer, Elliott Brothers (London) Ltd., Elstree Way, Borehamwood, Herts, quoting Ref. 398. W 2197

TECHNICAL ENGINEERS and assistants required for development work on radio and television valves. Vacancies at all levels. Some previous experience on comparable work desirable. Salary commensurate with experience. Write to Personnel Department, The M.O. Valve Co., Ltd., Brook Green, Hammersmith, W.6, quoting Ref. T.A./CHE. W 1049

TECHNICAL EXECUTIVE to administer and operate the technical policy of the Guided Weapons Division of a leading British Company in its field, engaged in the design and development of specialised ancillary equipment for guided weapons projects. A good Degree, with honours, or at least relative professional qualifications backed by some specific theoretical and practical experience of electrical and hydraulic systems; servo-mechanisms; gyroscopes; and general instrumentation are imperative; while some aerodynamical knowledge and/or experience though not essential would be a useful asset. The post demands drive, enthusiasm, initiative and administrative ability where a proven record of past achievement will justify a starting salary of upwards of £2,000 p.a. Age range 35-50. Staff Pension Scheme and housing assistance. Send full record and salary required to Box No. W. 2186.

TECHNICAL SALES REPRESENTATIVES required. Applications are invited from men of approximately 25 to 35 years of age, preferably with previous electronic laboratory experience. The positions are permanent and progresive and offer ample scope to men possessing the necessary drive and initiative. Applications, which will be treated in strict confidence, should give full details of qualifications and previous experience to Box No. W 2081.

TEST ENGINEERS. E. K. Cole Ltd., Southend-on-Sea, require Test Engineers with experience of Radio/T.V. test gear and measurements. Theoretical knowledge to C. & G. Grade 3 or equivalent essential. Apply Personnel Manager. W 2196

TEST ROOM SUPERVISOR required by Electronic and Radar firm of International repute, for appointment which will provide an outstanding opportunity to the successful applicant in an entirely new production group located in the South Coast area. Essential qualifications are:—(a) Good technical background. (b) Experience of the testing requirements associated with the production of microwave, radar, servo and pulse equipment. (c) Ability to organize and control staff. Superannuation scheme exists and housing assistance may be given. Write fullest details of education, experience and age to Box No. W 2105.

THE ASSOCIATED ETHYL COMPANY LIMITED require an Engineer or Physicist with Degree, for the design, development and construction of instruments for use in research programmes on I.C. Engines and I.C. engined vehicles at their Engine Laboratory, Bletchley. Attached to the Laboratory is a cafeteria where subsidised lunches are served. The selected applicant will be eligible to join Company's Contributory Pension Scheme. Applications giving age, education, qualifications and experience should be sent to:—The Office Controller, The Associated Ethyl Company Limited, Engine Laboratory, Watling Street, Bletchley, Bucks. W 2221

THE ENGINEERING DEPARTMENT of Sunvic Controls Ltd., a subsidiary of Metro-Vickers Electrical Co. Ltd., at Harlow, Essex, is building up a team to pursue the development and design of pneumatic, electronic and electromechanical instruments in connexion with important projects covering process control in the oil, chemical, atomic energy and allied fields. Good prospects of advancement exist in this rapidly growing organisation for men with initiative and good technical qualifications in Engineering and Physics. Apply Chief Engineer, Sunvic Controls Ltd., Harlow. W 2214

THE ENGLISH ELECTRIC CO., LTD., Luton, have an interesting vacancy for work on the development of new ideas in Microwave circuitry, Waveguides and Miniaturisation. Apply with full particulars and quoting Ref. 1160C to Dept. C.P.S. 336/7 Strand, W.C.2. W 2189

THE ENGLISH ELECTRIC CO., LTD., Kidsgrove Works, Staffordshire, have an interesting vacancy for a suitable man to take charge of a manufacturing unit involving metal/glass sealing and vacuum techniques, assembly work and control of associated labour. Applicants should have had experience in thermionic valve manufacture and experience in handling shop labour. Write giving full details of experience and qualifications to Ref. 1331, Dept. C.P.S. 336/7 Strand, W.C.2. W 2212

THE EXPANSION of our three and four-year courses has created vacancies for assistant lecturers, Grade B. Applicants for these posts should be Graduates in Electrical Engineering or Physics and possess industrial experience in communications or Electronics, with preferably some instructional experience. The posts are permanent with a generous pension scheme associated. Salary is in accordance with the London Burnham Technical Scale £490-£765 per annum with appropriate allowances for Degree, training and experience. Applications, stating age, qualifications and experience to:—The Principal, E.M.I. Institutes, 10 Pembridge Square, London, W.2. W 2244

THE ENGLISH ELECTRIC CO., LTD., Guided Weapons Division, Luton, require Physicists, Light Current Engineers or Mathematicians with an engineering bias for the development of a wide range of analogue computing devices such as differential analysers, equation solvers, resistance network computors and data transmission systems. Senior men with previous experience of this or allied fields and a Degree or H.N.C. (electrical) are required to design and supervise construction of complete computors. Junior posts require men for detail development of computor units and for liaison with workshops and drawing office. This is an opportunity to enter a new and expanding industry. Posts are progressive and a pension scheme is in operation. Good working conditions in new, well equipped laboratories. Applications, quoting Ref. SA50, should be sent to Dept. C.P.S., 336/7 Strand, W.C.2. W 2172

THE GENERAL ELECTRIC CO., LTD., Brown's Lane, Coventry, require Senior and Junior Electronic Development Engineers for work on Guided Weapons and like projects, particularly in the field of Microwave and Pulse Applications. Mechanical Development Engineers, Designer Draughtsmen and Draughtsmen, preferably with experience of Radar type equipments, also required for the above projects. Salary according to age, qualifications and experience. Apply by letter, stating age and expericince to the Personnel Manager (Ref. R.G.). W 169

THE McMURDO INSTRUMENT CO., LTD., Ashtead, Surrey, have the following vacancies in their Development Group. Applicants must be of British birth. (a) Electronic Development Engineers (2) for circuit and test gear development work. Applicants should have an Engineering Degree, H.N.C. or A.M.I.E.E. and be capable of working on their own initiative under the general guidance of a Section Head. (b) Technical Assistants (2) required for general development work on mechanical and electrochemical development. Applicants should preferably have O.N.C. or equivalent in an Engineering subject. and should be capable of making up development samples from rough sketches and sorting out experimental results, etc. (c) Laboratory Assistants to assist Development Engineers on Electrical and Mechanical work. (d) A detail Draughtsman with experience in design of small electrical components, etc. Apply in writing to The Personnel Manager. W 1058

THE PLESSEY COMPANY LIMITED. Development Engineers are required immediately in the Company's laboratories, for interesting and responsible work on the development of fractional horse power motors. Applicants should have H.N.C. or equivalent qualifications, preferably with practical training and experience in this field. Salary within the range £600-£1,000 per annum, according to age, qualifications and experience. Applications, giving full details should be addressed for the attention of the Personnel Manager, Vicarage Lane, Ilford, Essex. W 2220

TECHNICAL WRITER (ELECTRONICS) required. Applicants must have similar previous experience, including editing and layout, and have ability to write on electronic and radar equipment. Good salary and conditions. Pension Scheme. Apply with full details, including salary, quoting No. 1485 to Personnel Manager, Sperry Gyroscope Co., Ltd., Great West Road, Brentford, Middlesex. W 2199

TRANSFORMER DESIGN ENGINEER. Ferranti Ltd., Edinburgh, invite applications for the above vacancy in their Edinburgh works. The duties involve the designing of those types of Transformers normally used in Electronic Circuits (power, audio frequency, pulse, etc.), also the engineering of new ranges of such components for production purposes. Applicants should have experience in these duties and possess minimum technical qualifications of H.N.C. or equivalent standard but preference will be given to holders of a University Degree or Diploma. A commensurate salary will be paid. Staff Pension Scheme. Good working conditions and prospects. Apply quoting Ref. TDE/TD and giving full details of training, qualifications and experience to the Personnel Officer, Ferranti Limited, Ferry Road, Edinburgh, 5. W 2215

TRANSFORMER DESIGNER required for development projects involving audio-frequency power transformers, pulse transformers, oil-filled

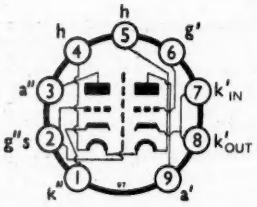
CLASSIFIED ANNOUNCEMENTS
continued on page 12

Osram VALVES for BAND III TELEVISION

B319 **Cascode R.F. amplifier**

LZ319 **Triode pentode frequency changer**

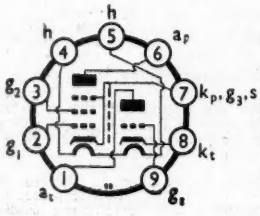
Introduced to meet the special 'front end' requirements of V.H.F. television receivers, these new OSRAM valves enable a high performance to be obtained at these frequencies with simple and inexpensive circuitry.



B319 Double triode designed for use as a series cascode R.F. amplifier with the accompanying advantages of high gain and good signal to noise ratio. The high slope at low anode voltage ensures efficient operation at H.T. supplies of 180V. The maximum heater-cathode has been increased to 250V to meet the special requirements of this application.

Heater	
I_h	0.3A
V_h	7.0V
Characteristics (per system)	
V_a	90V
V_g	−1.5V
I_a	12 mA
μ	24
r_a	4 kΩ
g_m	6 mA/V

Base B9A



LZ319 Triode pentode designed for use as a frequency changer following the B319 cascode amplifier. The LZ319 operates efficiently at H.T. voltage of 170-180, and gives a high conversion gain with standard circuitry.

Heater			
I_h	0.3A		
V_h	9.0V		
Characteristics	pentode system	triode system	
V_a	170	100	V
V_{g2}	170		V
V_{g1}	−2	−2	V
I_a	10	14	mA
μ_{g1-g2}	50		
μ		20	
r_a	400	4	kΩ
g_m	6	5	mA/V

Base B9A

Write to the Osram Valve & Electronics Dept. for further information

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

units, etc. Apply stating age, qualifications and experience to the Personnel Manager (Ref. R.G.), The General Electric Co., Ltd., Brown's Lane, Allesley, Coventry. W 192

TWO PHYSICISTS OR ELECTRICAL ENGINEERS are required to develop electronics for infra-red apparatus of advanced design. A flair for devising electronics circuits is required, with a special interest in high stability L.F. Amplifiers, Servo Mechanisms and circuits for improving signal to Noise Ratio. B.Sc. standard or equivalent is expected and applicants should be under 30. Apply in writing, stating age, education, Industrial experience and salary required to Sir Howard Grubb, Parsons & Co., Optical Works, Walkergate, Newcastle-upon-Tyne 6. W 2205

URGENTLY REQUIRED. Young single men as Electronic Wiremen, also Junior and Senior Test Engineers in connexion with Television Cameras and ancillary equipment. Apply in writing to Personnel Officer, Dept. 24, Pye Ltd., Radio Works, Cambridge. W 2128

VACANCIES EXIST for Technical Engineers in London Area as shown hereunder: (a) Mechanical Design Engineers with experience of gas turbine engines and/or hydraulic equipment. Salary £700 to £900 p.a. (b) Senior Design Engineers in connexion with microwave, servo and electronics development. Salary range up to £1,000 p.a. (c) Production Engineer experience to cover small batch production of electronic equipment and/or light electro-mechanical instruments. Salary £900 p.a. (d) Senior Estimators. Planning Engineers and Time Study Engineers. Experience as for (c). Salary up to £850, £750 and £700 respectively. Replies giving full details of age, qualifications and experience should be addressed to A.A., London Appointments Officer, 1-6 Tavistock Square, W.C.1. W 2218

VICKERS-ARMSTRONGS LIMITED, Weybridge Works: Guided Weapons Development. Applications are invited from experienced Engineers for senior staff appointments in the following grades:—Electronic Engineer to lead Group on Servo Control and Simulator Design. Electro-Mechanical Designer—to develop small mechanisms. Vacancies also exist for: Engineers, Technical Assistants, Draughtsmen (Senior, Intermediate, Junior and Trainee), Laboratory Assistants and Mechanics. For work on structuaral, electronic, electrical and mechanical engineering development. Suitable academic qualifications are required: Engineers and Technical Assistants—graduate or equivalent Draughtsmen and Laboratory Assistants —H.N.C. standard. Applications should be made to: Employment Manager, Vickers-Armstrongs Limited, Weybridge Works, Weybridge, Surrey. W 2075

VICKERS-ARMSTRONGS LTD., Crayford, Kent, invite applications to fill the following vacancies. 1. Honours Graduates to engage in research and development work on commercial electronic computing machines and devices. 2. Engineers and Technicians to engage in development and design of elecmercial electronic computing machines and devices. Qualifications: University Degree, Higher National Certificate or equivalent. 3. Electrical Draughtsman to engage in the design of electronic commercial computing machines and devices. 4. Electronic Technicians with servicing experience of radio, radar and electronic equipment, especially pulse circuitry. Theoretical training to O.N.C. or equivalent standard. Selected candidates will be given training in testing and adjusting Electronic Computors. 5. Junior and Senior Electrical Draughtsmen accustomed to work concerned with circuit and cable lay-out, particularly in connexion with Naval and Military equipment. Experience in the design of small electrical apparatus and lay-out of electronic equipment will be an advantage. 6. Graduate Electrical Engineers, age about 30, with Degree or H.N.C. and practical experience in servos, electronics or telecommunications, for development work on low-power servo systems. Applications should be made in writing to the Manager, Engineering Department and Labour. W 2203

WIREMAN for modern research laboratory, capable of working to verbal instruction and able to do original layouts. City and Guilds or National Certificate an advantage, at least three years' experience imperative. (Ref. 71.) Write in detail quoting reference No. of position sought to: The Personnel Dept. (Technical Employment), De Havilland Propellers Limited, Hatfield, Herts. W 2089

WIREMAN for small specialized factory, capable of working to verbal instructions and sketches, able to originate layouts. Experience with X-Ray or allied apparatus an advantage. Slough district. Apply Box No. W 1065.

Further "Situations Vacant" advertisements appear in display style on pages 81, 93, 105 & 106.

SITUATIONS WANTED

DEPARTMENT MANAGER, i/c design, production, buying, sales, etc. Wide range precision electronic and mechanical industrial and special instruments and radar desires high post at commensurate salary where drive and abilities are valued. Box No. W 1075.

ELECTRICAL / ELECTRO - MECHANICAL ENGINEER with good general experience in Electrical (apprenticeship) and Mechanical Engineering, Research and Development, Design, Production of Electro-Mechanical/Electronic Apparatus and Equipments, ex-R.A.F.V.R. (Electrical-Supervisory), requires appointment where his experience will be of mutual advantage. Available immediately. Further details from Box No. W 2176.

EXPERIENCED TECHNICAL AUTHOR of repute seeks work, whole or part-time. Thorough knowledge of telecommunications and industrial electronics, also Patents procedure. Box No. W 1056.

LATE CHIEF DEVELOPMENT ENGINEER, industrial electronic equipment, at present otherwise employed, wishes to return to this field in a post where originality of conception would be an asset. Box No. W 1057.

PRODUCTION AND TECHNICAL ENGINEER, aged 36, graduate. Considerable experience of economic design and production of light electro-mechanical devices. Holder of patents. Administration experience. Seeks responsible post with small or medium-sized company. Box No. W 1054.

FOR SALE

A.F. SIGNAL GENERATOR for Sale. Guaranteed in perfect condition, covers 20c/s to 50kc/c approx. 1 per cent, sine and square outputs, attentuator, etc., in strong case complete with full instruction sheets. Bargain £9 only, must sell. Send s.a.e. for full details. Box No. W 1034.

FOR SALE. £20. ONO complete unused kit for E.E. home built Televisor including all valves, Ferranti Tube, Gardner mains Transformer chokes. Scanco line Transformer Focus coil. Scanning coils as specified, nearly all wiring chassis work completed. Owner posted abroad. Box No. W 1047.

GERMANIUM DIODES 1s. each. Large quantities cheaper. BDC, 591 Green Lanes, London, N.8. W 1040

MAGSLIPS at 1/10th to 1/20th of List Prices. Huge stocks. Please state requirements. K. Logan, Grove Road, Hitchin 1744, Herts. W 183

METALWORK. All types cabinets, chassis, racks, etc., to your own specifications. Philpott's Metal Works Ltd. (G4BI), Chapman Street, Loughborough. W 2000

OIL FILLED CONDENSERS. Dubilier 0·5 × 0·5 MFD — 2,200 volts. Quantity at large discount. Box No. W 2125.

POLYTHENE BLOCK (free from bubbles) is now available in a wide range of sizes. Recommended for lathe-turning and shaping to make insulating bushes, coil and choke formers and many electrical components where moulding is not practicable. Sample block (approximately) 6 in. × 6 in. × 1½ in., 17s. 6d. post free. Cash with order or C.O.D. Theraplastics Ltd., 35 Cornwall Gardens, London, S.W.7. WEStern 1382. W 1044

SINE-COSINE RESOLVERS (3 in. Magslip Transmitters No. 5, AP 10861). Brand new, each in maker's tin. Offered in quantity at less than one tenth of cost. Export inquiries invited. P. B. Crawshay, 166 Pixmore Way, Letchworth, Herts. W 153

SURPLUS to requirements 300 lb. permalloy. C. Laminations pattion 15A. 0.015 in. thick in makers packing. Send offers to, Austin Walters & Son Ltd., Ayres Road, Manchester, 16. W 1048

THERMOCOUPLE WIRES.—Insuglass Covered —Various gauges and combinations of alloys in stock. Inquiries for long or short lengths to EE/TW Department, Saxonia Electrical Wire Co., Ltd., Roan Street, Greenwich, S.E.10. W 1989

WE ALWAYS have for disposal large stocks of surplus cardboard boxes, mainly small sizes. Send details of dimensions required for samples by return. Hinton & Boulton, 573/5 High Road, Ilford, Essex. W 1059

EDUCATIONAL

CITY & GUILDS (Electrical, etc.) on " No Pass—No Fee " terms. Over 95 per cent successes. For full details of modern courses in all branches of Electrical Technology send for our 144-page handbook—Free and post free. B.I.E.T. (Dept. 337C), 29 Wright's Lane, London, W.8. W 142

COVENTRY TECHNICAL COLLEGE. Session 1954-55. Electronic Engineering. Applications invited for entry to three year full-time course commencing September, 1954, from those requiring comprehensive training to advanced level in Electronic Engineering, qualifying for technical posts in radio, telecommunications, television and industrial electronics. Syllabus will cover requirements of City and Guilds, Brit. I.R.E., and I.E.E. examinations. Entry age 16 or over. Application forms and further information from Principal, Technical College, The Butts, Coventry W 2113

FREE Brochure giving details of courses in Electrical Engineering and Electronics, covering A.M.Brit.I.R.E., City and Guilds, etc. Train with the Postal Training College operated by an Industrial Organisation. Moderate fees. E.M.I. Institutes, Postal Division, Dept. EE/29, 43 Grove Park Road, London, W.4. W 190

T.V. AND RADIO—A.M.Brit. I.R.E., City & Guilds, R.T.E.B. Certificate, etc., on " No Pass—No Fee " terms. Over 95 per cent successes. Details of Examinations and Home Training Courses in all branches of Radio and T.V. Write for 144-page handbook — Free. B.I.E.T. (Dept. 337H), 29 Wrights Lane, London, W.8. W 187

UNIVERSITY MATHEMATICAL LABORATORY. Cambridge. Diploma in Numerical Analysis and Automatic Computing. A course of the Diploma in Numerical Analysis and Automatic Computing will be held in the Mathematical Laboratory during the academic year 1954/5. Students interested in taking the course, which covers both mathematical and engineering aspects of the subject should consult the Director of the Mathematical Laboratory. W 2224

SERVICE

AUTOMATIC CAPACITY available. Small modern plant. Deliveries to customers requirements. London area deliveries by own vans. Box No. W 1055.

WEBB'S SERVICE DEPT. for complete renovation of complex communication receivers of any make. Test report issued showing sensitivity selectivity, signal/noise equal to, or better than, maker's original figures. Webb's Radio, 14 Soho Street, London, W.1. W 196

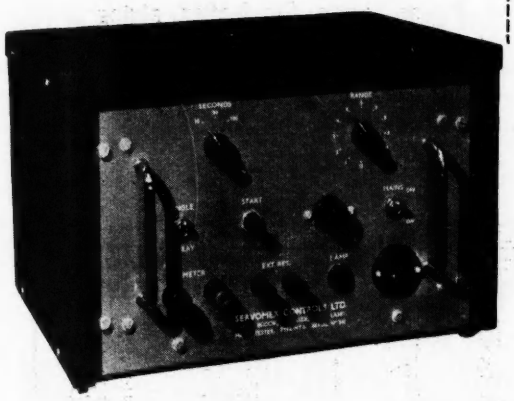
AGENCIES

SELLING AGENT required for firm commencing manufacture of Vitreous Enamelled Resistors. Partnership offered if agent suitable. Box No. W 1074.

From the range of

SERVOMEX

Electrical Control Instruments



Meter Tester

TYPE M.T.I.

This device is designed to eliminate the nuisance of "sticky meters". In effect it sweeps the needle from a slightly negative value to full scale at a completely steady speed, so that the slightest unsteadiness indicates a faulty movement.

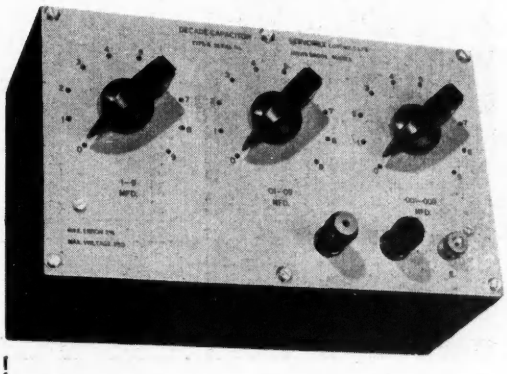
- *Sweep times of 10, 30 and 100 seconds.*
- *12 ranges of current from 0 to 10 milliamps.*
- *Stabilised against mains changes, including sharp transients.*
- *Repetition facilities gives semi-automatic operation for large numbers of meters.*

Decade Capacitor

TYPE A.

This condenser box is offered at a low price to meet the demand for an instrument suitable for serious work, but not quite of "laboratory standard" type.

- *0.001 mfd. to 0.999 mfd. in three decades*
- *350 volts working.*
- *2% guaranteed accuracy.*
- *1,000 megohms leakage resistance.*
- *Re-designed to give greatly increased mechanical strength.*



Please write for data sheet

SERVOMEX CONTROLS LIMITED

CROWBOROUGH HILL, JARVIS BROOK, SUSSEX TEL. CROWBOROUGH 1247

Approved to ENTIRELY NEW Inter-Service Standards

A miniature range of Hunts Electrolytics approved to Inter-Service standards RCS 134 Issue 3 and RCL 134 Addendum Issue 2. Temperature range: −30° C to +70° C max. Please write for leaflet giving details of complete range.

Cap µF	Peak Working Volts at 70°C.	Max. R.M.S. Current at 50/c/s (mA)	Dimensions (inches) L.	D.	List Number	Inter-Service Cat. Number
TYPE L31/1. PATTERN CE4. CLASS HI						
50	25	70	1¼		JB 53AKZ	Z145512
100	25	100	1¾		JB 54KZ	Z145514
1000	25	600	3	1	JB 57KZ	Z145520
25	50	60	1¼		JB102BKZ	Z145508
50	50	100	1¾		JB103KZ	Z145513
500	50	450	3	1	JB106AKZ	Z145519
8	150	60	1¼		JB153BKZ	Z145502
16	150	90	1¾		JB154KZ	Z145505
32	150	160	1¾		JB181KZ	Z145509
8	350	75	1¾		JB403KZ	Z145503
16	350	120	1¾		JB405KZ	Z145506
32	350	225	2	1	JB407AKZ	Z145510
4	450	50	1¾		JB552KZ	Z145501
8	450	100	1¾		JB553BKZ	Z145504
16	450	175	2	1	JB554AKZ	Z145507
32	450	275	3	1	JB555AKZ	Z145511
TYPE L32/1. PATTERN CE5 CLASS HI						
3000	25	1100	4½	1⅜	KB 62KZ	Z145557
1500	50	1000	4½	1⅜	KB111KZ	Z145555
60	350	350	2	1⅜	KB430KZ	Z145552
100	350	450	3	1⅜	KB411KZ	Z145554
32	450	275	3	1	KB555BKZ	Z145551
60	450	450	3	1⅜	KB581KZ	Z145553
TYPE L32/3. PATTERN CE6. CLASS HI						
32+32	350	200	2	1⅜	KB417KZ	Z145601
60+100	350	400	4½	1⅜	KB420KZ	Z145603
60+250	350	400	4½	1⅜	KB422KZ	Z145605
100+200	350	550	4½	1⅜	KB423KZ	Z145606
32+32	450	300	3	1⅜	KB564AKZ	Z145602
60+100	450	550	4½	1⅜	KB565KZ	Z145604

In accordance with Government specification all units are supplied insulated by an approved sleeve the dimensions being increased accordingly by ⅛" on the length and 1/16" on the diameter.

REGISTERED TRADE MARK

HUNTS CAPACITORS

THE TRADE MARK OF RELIABILITY

A. H. HUNT (Capacitors) LIMITED
WANDSWORTH · LONDON · S.W.18
Tel: BATtersea 1083-7 **Est. 1901**
And in Canada — HUNT CAPACITORS (Canada) Ltd., AJAX, ONTARIO

Potted *with 'Araldite'*

For potting and sealing electrical components, 'Araldite' is without equal. In addition to its remarkable electrical and mechanical qualities, 'Araldite' offers outstanding adhesion to metals, whilst shrinkage on setting is exceptionally low. 'Araldite' is resistant to high temperatures, humidity and corrosive agents and satisfies the Services specification for the sealing and potting of electrical equipment. This new epoxy resin is being extensively used for potting and sealing components for radio, electronics and electrical engineering. Our illustration shows an inductance and mica dielectric capacitor network for shaping a transmitted radar pulse. Potting in 'Araldite' ensures hermetic sealing and permits a reduction in size and weight.

Photo by courtesy of Telegraph Condenser Company Ltd.

These are the new Epoxies!

'Araldite' (regd.) epoxy resins are obtainable in the following forms:—

- *Hot and cold setting adhesives for metals and most other materials in common use.*
- *Casting Resins for the electrical, mechanical and chemical engineering industries.*
- *Surface Coating Resins for the paint industry and for the protection of metal surfaces.*

Full details will be sent gladly on request.

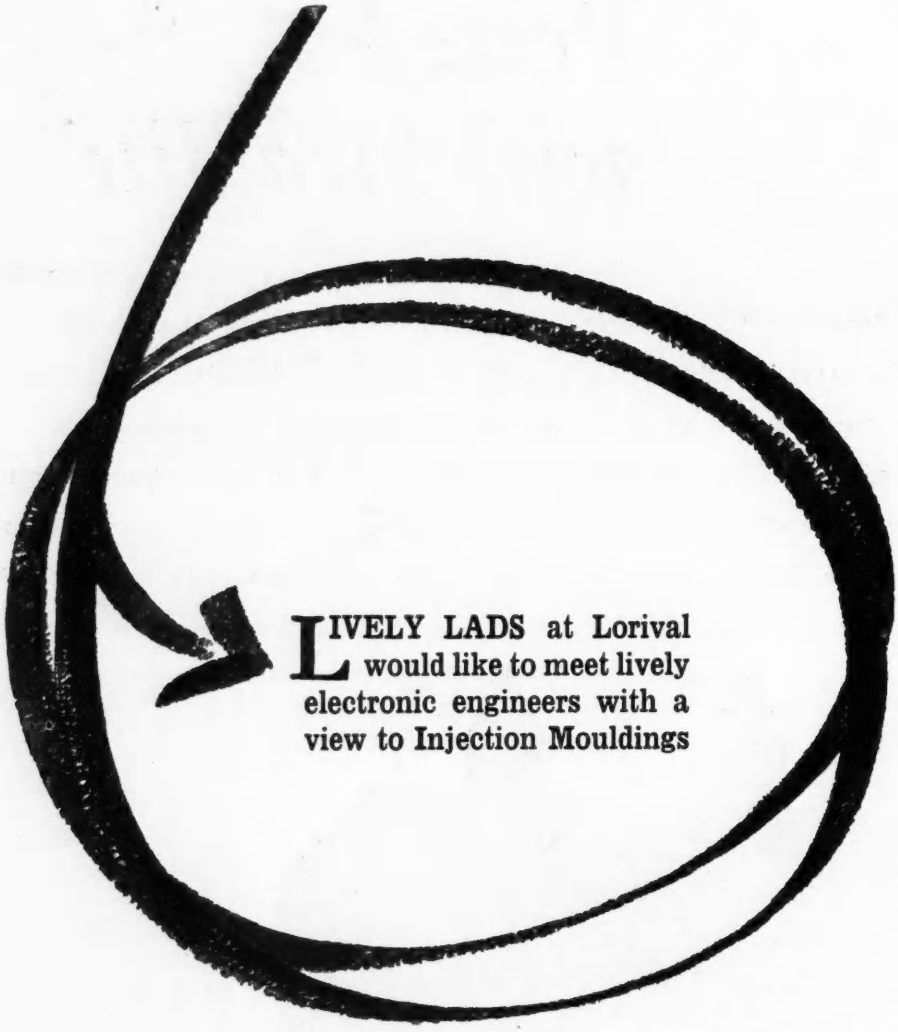
Aero Research Limited

A Ciba Company, DUXFORD, CAMBRIDGE. Telephone: Sawston 187

'Araldite'

epoxy casting resins

® 264-65



LIVELY LADS at Lorival would like to meet lively electronic engineers with a view to Injection Mouldings

LORIVAL PLASTICS

Lorival Plastics have a large range of Injection Machines and a full range of thermo-plastic materials.

UNITED EBONITE & LORIVAL LTD · LITTLE LEVER · NEAR BOLTON · LANCS

AVO

REG. TRADE MARK

WIDE RANGE *Signal* GENERATOR

An inexpensive yet precision instrument designed especially to meet the exacting needs of the modern service engineer and laboratory technician. With six frequency ranges covering 50 Kc/s to 80 Mc/s, its accuracy is better than ±1% of the scale reading.

50 Kc/s-150 Kc/s	1.5 Mc/s-5.5 Mc/s
150 Kc/s-500 Kc/s	5.5 Mc/s-20 Mc/s
500 Kc/s-1.5 Mc/s	20 Mc/s-80 Mc/s

Scale sub-divisions provide more than adequate discrimination for use in television circuits. Note the starred features below, which combine to maintain a minimum of less than 1μV up to 20 Mc/s and less than 3μV between 20 Mc/s and 80 Mc/s.

★ **OUTPUT** 1
Coaxial socket for attenuated output. Force socket located totally within H.F. compartment.

MAINS TRANSFORMER 2
Marked tagboard for inputs of 100-130V and 200-260V A.C. 50/60 c/s.

★ **CAST ALUMINIUM H.F. COMPARTMENT & CHASSIS** 3
Large number of fixing holes for H.F. compartment cover ensures excellent electrical bonding and good screening.

FUSE 4
Easily accessible when replacement is necessary.

VALVE 5
Standard types run at a rating to ensure long life.

TURRET COIL SWITCHING 6
Standard "AVO" practice.

★ **ATTENUATOR SYSTEM** 7
Employs close tolerance, high stability midget carbon resistors, low reactance rotary potentiometer modified for H.F. operation with carefully designed screening.

Other features include:

ILLUMINATED SPOT RANGE SELECTOR
Gives rapid identification of operational band with intensified lighting round precise frequency. Fine hair line gives close discrimination, particularly on high frequencies.

STOPS
Separate stops prevent turning of dial with respect to condenser.

★**MAINS FILTER SYSTEM**
This is screened from main electrical assembly.

BUSHING PLATES
provide additional rigidity for rotary controls.

SLOW MOTION DRIVE
substantially free from backlash.

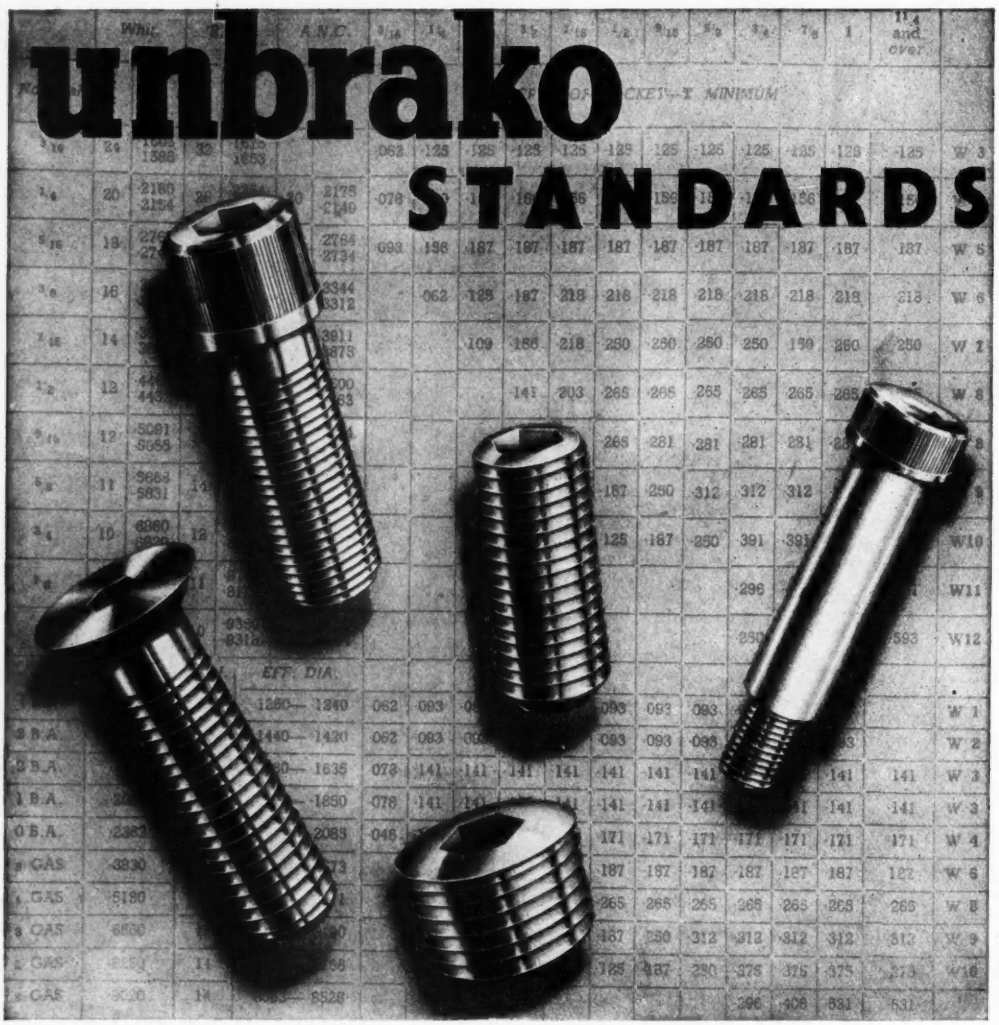
MAINS MODEL 100-130V and 200-260V A.C. 50-60 c/s £30
or BATTERY MODEL £30

Sole Proprietors and Manufacturers :—

The AUTOMATIC COIL WINDER & ELECTRICAL EQUIPMENT CO. LTD.
WINDER HOUSE • DOUGLAS STREET • LONDON • S.W.1 *Telephone: VICTORIA 3404/9*

S.G.2

unbrako STANDARDS



What are Unbrako standards?

UNBRAKO

Didn't you know? Well, they're the five types of socket head screws which you see illustrated. Precision formed, close tolerance screws which meet the everyday needs of engineering

Available in B.S.F., Whitworth, B.A., Metric, A.N.C., A.N.F., and Unified threads in sizes from 8B.A. cap screws and 6B.A. set screws.

Made to the exacting quality specification
of the world's largest specialist screw manufacturers,
they are always obtainable from Unbrako Distributors throughout the world.

UNBRAKO SOCKET SCREW CO. LTD.
COVENTRY ENGLAND

B T-H

Photo-Electric Relay

a ***FLASH*** *of light*

effects 'ON'/'OFF' control of ELECTRIC POWER

The standard relay is extremely sensitive, and responds to the incidence or interruption of a beam of light, of intensity as low as 1-foot candle, and of duration as short as 1/10th of a second.

Applications include:—limit switch (as used in steelworks and other heavy industries); control of street lighting and interior illumination, liquid level, register, side lay, dimension, weighing, counting, alarm devices, etc.

THE
BRITISH THOMSON-HOUSTON
COMPANY LIMITED, RUGBY, ENGLAND

Member of the AEI group of companies

A4762

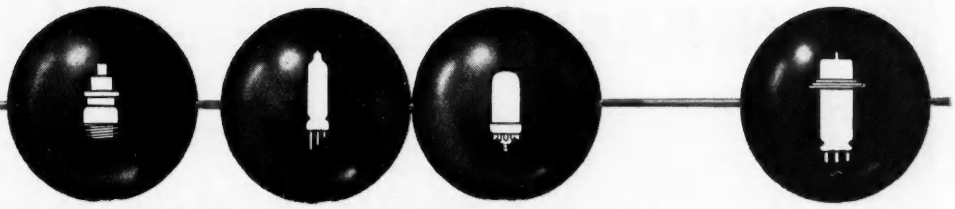
for radio ceramics

STEATITE & PORCELAIN PRODUCTS LTD.

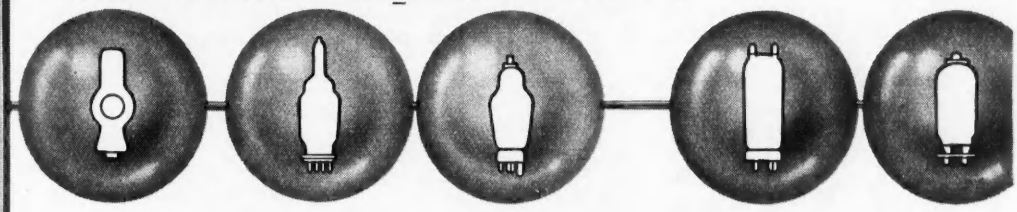
Stourport-on-Severn, Worcestershire. Telephone : Stourport 111. Telegrams : Steatain, Stourport

SP88

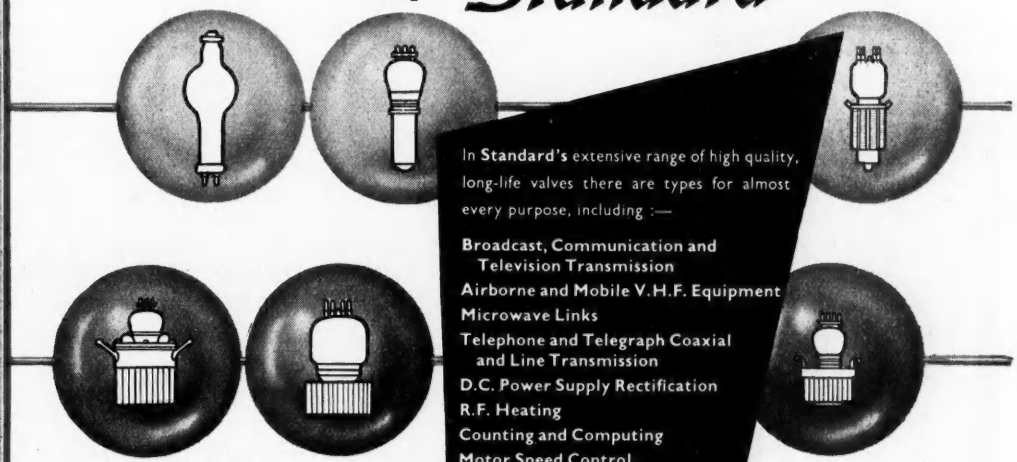
You can count on



Communication and Industrial Valves



by *Standard*



In **Standard's** extensive range of high quality, long-life valves there are types for almost every purpose, including :—

- Broadcast, Communication and Television Transmission
- Airborne and Mobile V.H.F. Equipment
- Microwave Links
- Telephone and Telegraph Coaxial and Line Transmission
- D.C. Power Supply Rectification
- R.F. Heating
- Counting and Computing
- Motor Speed Control
- Welding Control
- Medical Diathermy
- Voltage Stabilisation
- X-Ray
- Vacuum Measurement
- Thermocouples

Standard engineers are always available for consultation ; and designers and technicians in most branches of industry, who may wish to avail themselves of *Standard's* long experience in valve engineering, can be assured enthusiastic co-operation.

Standard Telephones and Cables Limited

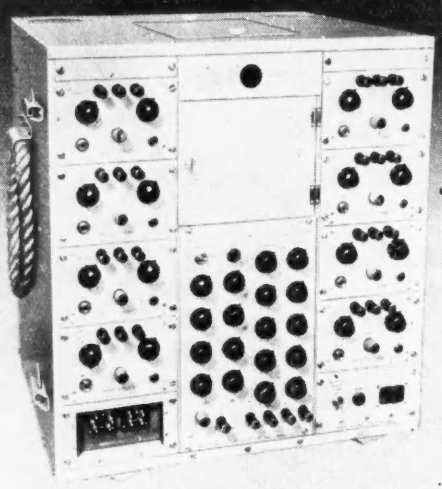
Registered Office : Connaught House, 63 Aldwych, London, W.C. 2.

RADIO DIVISION · OAKLEIGH ROAD · NEW SOUTHGATE, LONDON, N.11

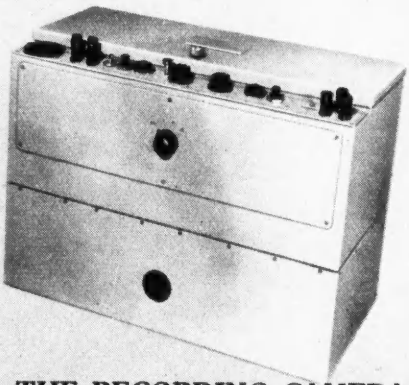
An Example of a

MINIRACK

COMPLETE OSCILLOGRAPH EQUIPMENT

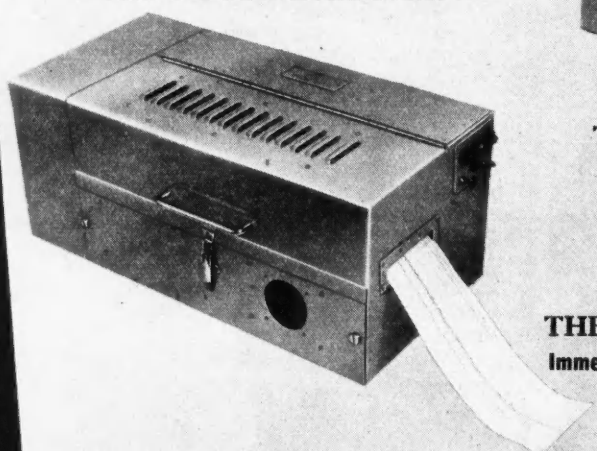


THE CATHODE RAY TUBE UNIT
(Nine Channel)



THE RECORDING CAMERA
(200 ft Rolls 120 mm wide)

THE AUTO-DEVELOPER



THE PROCESSED RECORD
Immediately available for examination

Write for catalogues describing all our Transducers, Amplifiers, Single and Multi-Channel Oscillographs, Cameras, Auto-Developers and accessories.

SOUTHERN INSTRUMENTS LIMITED
CAMBERLEY SURREY

Telephone : Camberley 2230 (3 lines) *Telegraphic Address : " Minrak," Camberley, England.*

The new Mk. III Camera with 4½" or 3" image orthicon tube . . .

The use of the new Marconi camera BD 687 with 4½" or 3" image orthicon tube and the employment of better circuit techniques in the camera channels have reduced to a negligible degree such faults as black halos, edge effects and electronic ghosts; whilst resolution, grey scale and signal-to-noise ratios are greatly improved. Ingenious design has led to simplicity of control and provided for fully remotely controlled applications.

Besides the camera the channels BD 808/809 comprise a Camera Control and Preview Monitor, Regulated Power Supply Unit and Focus Supply Unit.

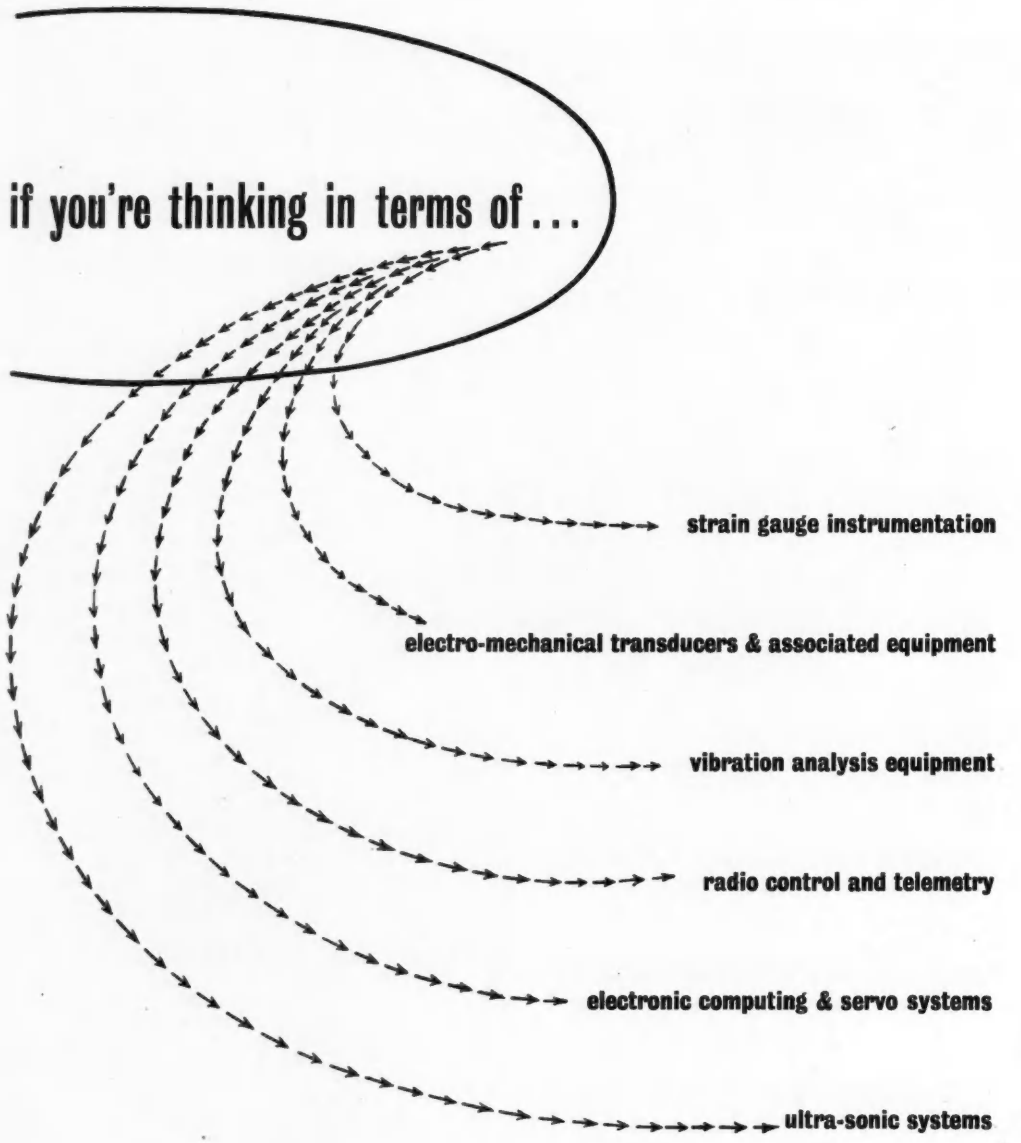
MARCONI

Complete Broadcasting and Television Systems

Marconi equipment has been installed in every one of the BBC Television transmitter stations and in the USA, South America, Canada, Italy and Thailand.

MARCONI'S WIRELESS TELEGRAPH CO. LTD., CHELMSFORD, ESSEX

LB 1


if you're thinking in terms of...
strain gauge instrumentation
electro-mechanical transducers & associated equipment
vibration analysis equipment
radio control and telemetry
electronic computing & servo systems
ultra-sonic systems

see SAUNDERS-ROE Electronics Division

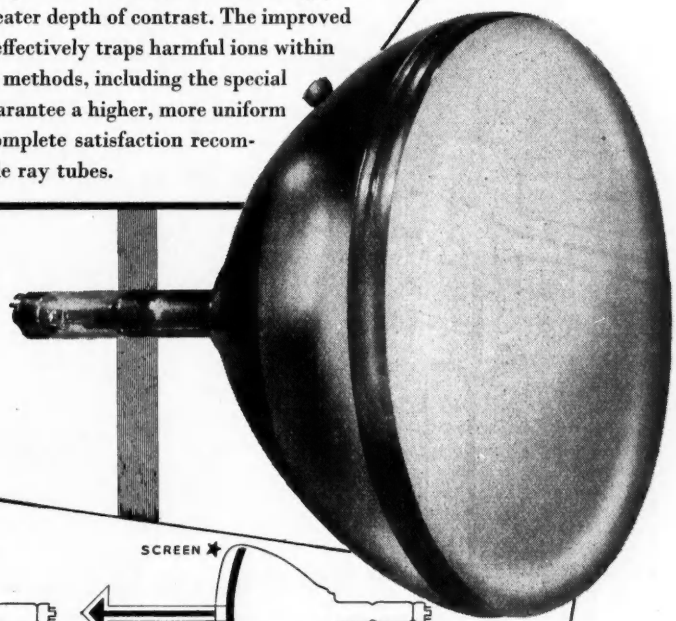
OSBORNE · EAST COWES · ISLE OF WIGHT

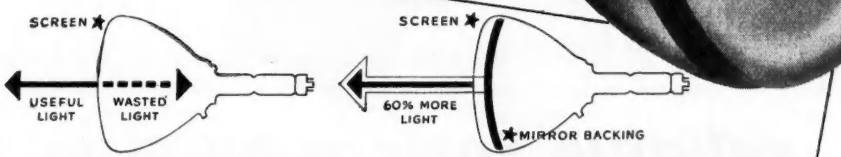
TELEPHONE: COWES 2211

Exhibiting at
Institution of Electronics (N.W. Branch)
ELECTRONICS EXHIBITION
College of Technology, Manchester
STAND J. July 14-20, 1954

Clearly—you get better pictures with this ALUMINIZED cathode ray tube

You cannot beat the new Ediswan Mazda Aluminized Cathode Ray Tubes for picture quality or length of life. Ediswan Aluminizing gives 60% brighter pictures with greater depth of contrast. The improved ion trap tetrode electron gun effectively traps harmful ions within the tube. Ediswan production methods, including the special in-line exhausting process, guarantee a higher, more uniform standard of efficiency. For complete satisfaction recommend Ediswan Mazda cathode ray tubes.





Without Aluminizing

Without Aluminizing, tubes waste half their light by backward reflection. To counteract this the brilliance must be increased which shortens tube life.

With Ediswan Aluminizing

Ediswan aluminized tubes have a mirror backing to the screen. All the light is thus thrown forward giving brighter, clearer pictures, and extra life.

Quicker Service

Ediswan are the only company to have 6 fully equipped cathode ray tube service Depots throughout Great Britain, thus providing better, quicker tube testing should the need arise. Also, 18 Ediswan District Offices carry stocks of tubes.

EDISWAN

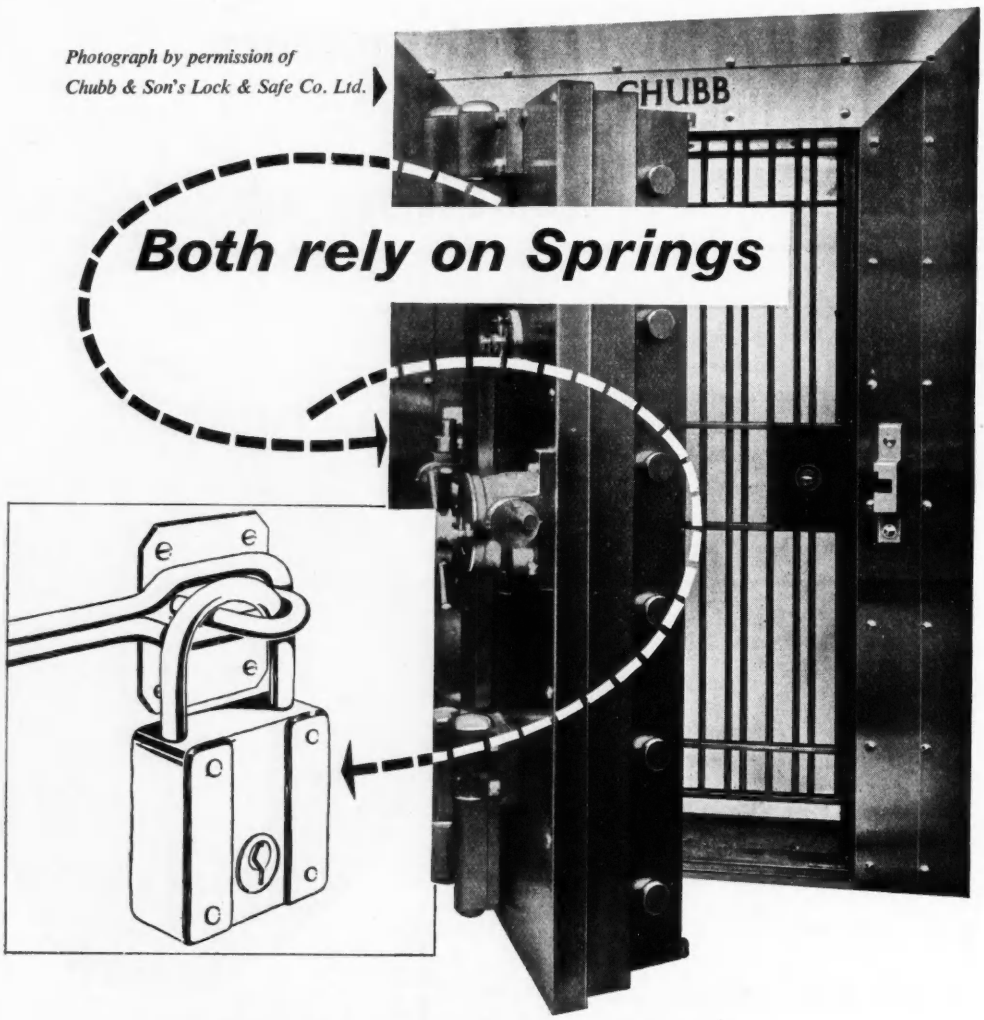
MAZDA ALUMINIZED CATHODE RAY TUBES

THE EDISON SWAN ELECTRIC COMPANY LIMITED

155 Charing Cross Road, London, W.C.2, and branches

Member of the A.E.I. Group of Companies

Photograph by permission of
Chubb & Son's Lock & Safe Co. Ltd.



Both rely on Springs

reliable Springs by

From the high precision spring required for a strongroom door to its simpler counterpart in a padlock, the right spring for the job is essential to ensure perfect performance. When your springs are designed and made by Salter, they are just right — not the cheapest obtainable but fit to work for ever.

SALTER

Service to Engineers since 1760

A tradition of quality in craftsmanship and materials is embodied in every Salter spring — you can depend on Salter for the *right spring for the job.*

Geo. Salter & Co. Ltd., West Bromwich

M-W.381

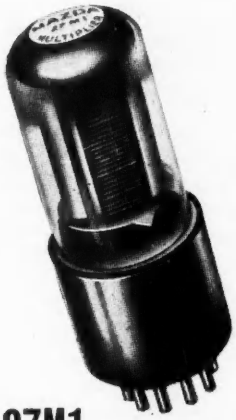


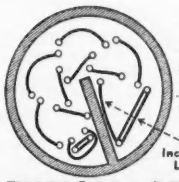
Photo-Electric Multipliers 27M1 and 27M2

for light operated relays, film scanning, facsimile transmission, and many Research and Laboratory investigations involving low light levels.

Now available for prompt delivery

27M1 The 27M1 is a nine stage high vacuum photo cell with high response in the visible region. When operated at 100 volts per stage it is capable of multiplying very small currents produced under weak illumination by an average value of one million times. Under normal operating conditions the resultant output current is a linear function of the exciting illumination. The frequency response is flat up to the frequencies at which transit time of electrons within the valve becomes a limiting factor.

Because of its great sensitivity, low noise level, low dark current and freedom from distortion the 27M1 may be used for light operated relays, film scanning, facsimile transmission and in scientific research involving low light levels. In many applications its small size is an advantage. List Price: £15.



The secondary cathodes, or dynodes, of these multipliers are arranged in cylindrical formation so that they are exceptionally compact.

TYPICAL OPERATION

Voltage between anode and secondary cathode K10	50 volts
Voltage difference per stage	100 volts
Maximum anode dark current (with 100 volts between anode and cathode K10)	0.25μA
Luminous sensitivity (taken on the basis of a lamp colour temperature of 2700°K and a light area of 5 mm x 20 mm)	20A/lumen
Current amplification (ratio of anode sensitivity/cathode sensitivity)	10^6

27M2 The 27M2 is a nine stage high-vacuum photo-cell similar to the 27M1 except that it has wider tolerances on the anode dark current necessitating a lower anode supply voltage with a resultant reduction in the current amplification to approximately one quarter of that obtainable from the 27M1. It is capable of multiplying very small currents produced under weak illumination by an average value of 250,000 times when operated at 80 volts per stage.

The 27M2 is suitable for the same applications as the 27M1 wherever the reduced magnification is acceptable. List Price: £6.

TYPICAL OPERATION

Voltage between anode and secondary cathode K10	50 volts
Voltage difference per stage	80 volts
Maximum anode dark current (with 80 volts between anode and secondary cathode K10)	0.25μA
Luminous sensitivity (taken on the basis of a lamp colour temperature of 2700°K and a light area of 5 mm x 20 mm)	2.5A/lumen
Current amplification (ratio of anode sensitivity/cathode sensitivity)	0.25×10^6

Either the 27M1 or the 27M2 may be used as a plug-in replacement for the American type 931A.
A special stabilised power unit providing a highly stable H.T. supply for photo-multipliers is available.
Full details on request.

EDISWAN

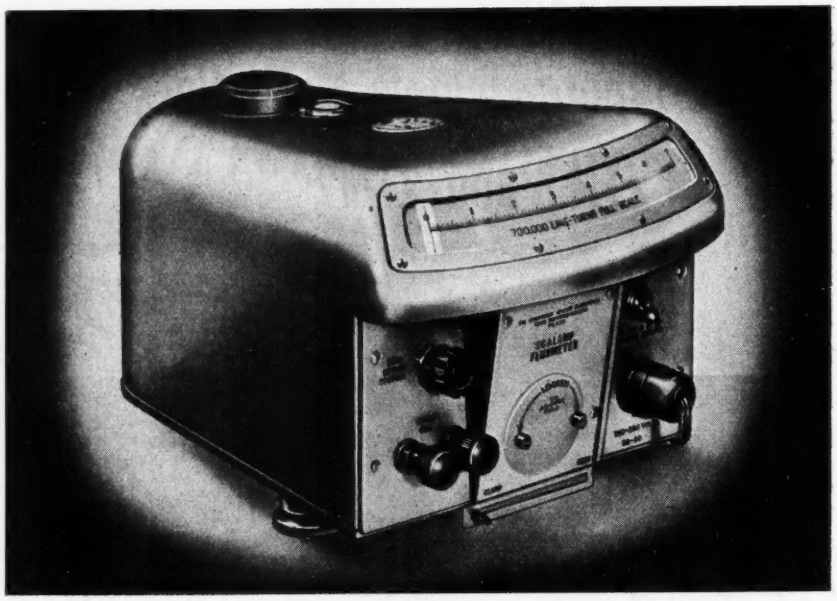
MAZDA

RADIO DIVISION

THE EDISON SWAN ELECTRIC COMPANY LIMITED

Member of the A.E.I. Group of Companies SVI

155 Charing Cross Road, London, W.C.2. *Telephone:* Gerrard 8660. *Telegrams:* Ediswan, Westcent, London



SCALAMP FLUXMETER

Excellent design and the selection of the most suitable materials are combined to give this new FLUXMETER a truly outstanding performance. The drift rate with a search coil of 10 ohms or less is 0.1 per cent. A two speed "return-to-zero" control is fitted enabling measurements to be made with rapidity and ease. A spirit level and levelling feet facilitate setting-up and the automatic and manual coil clamps safeguard the suspension in transit. The illumination of the lamp bulb is effected either by an external 4-volt battery or by mains supply through the built-in transformer. Two search coils of mean diameter 1 cm and of area turns of 10 or 100 sq. cm are available.

Please write for our descriptive leaflet quoting Cat. No. E.E. 8834

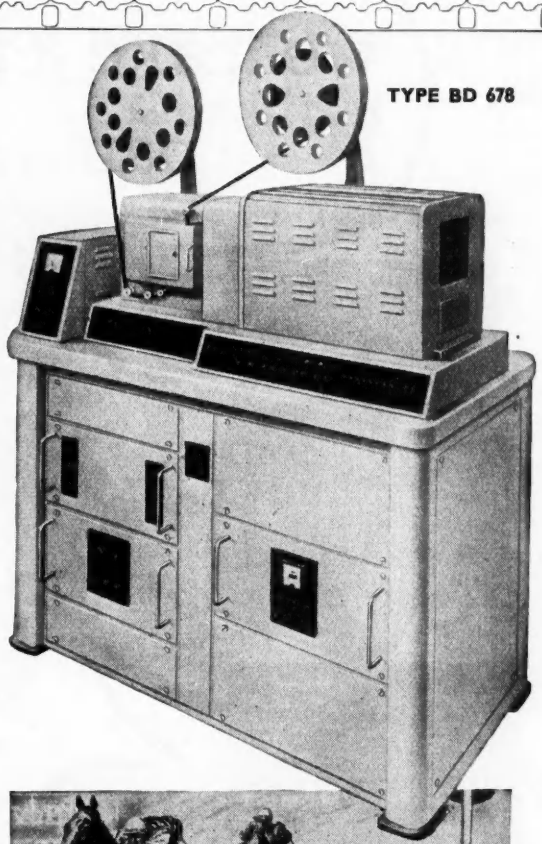
OUR NEW ILLUSTRATED CATALOGUE IS AVAILABLE ON REQUEST

SCIENTIFIC PYE INSTRUMENTS

W. G. PYE & CO. LTD., GRANTA WORKS, CAMBRIDGE, ENGLAND

WG.55

Flying Spot Telecine Equipment



TYPE BD 678

The equipment provides a television picture of exceptionally high quality from 16 mm. films and 2 x 2 in. miniature film slides. A 'fast pull down' type of film projector is used and a similar mechanism serves for television systems having field repetition rates of either 50 or 60 fields per second. Thus any type of fixed or moving prism system is obviated.

The 16 mm. Projector, Turret Slide Scanner, Optical Change-over Assembly, Flying Spot Scanning Unit and the PEC Amplifier are mounted on top of the steel cabinet which houses the auxiliary units and power units.

The equipment can be fully controlled locally and remote controlled for stopping and starting of the film projector, change-over from film to slides and selection of any one of eight slides.

Editions of the BD 678 are available for 405, 525, or 625 line systems

MARCONI

Complete Broadcasting and Television Systems

Marconi Equipment has been installed in every one of the B.B.C. Television transmitter stations and in the U.S.A., South America, Canada, Italy and Thailand

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED · CHELMSFORD · ESSEX

LB 2

They say we make a perfect pair...

..with excellent connections

To be exact, this is the 12 pin version of the Multi-Way Plug and Socket range, which covers 4, 8, 12, 20 and 28 ways. The range features unusually low insertion pressures, and embodies considerable experience in meeting humid conditions. Designed to overcome as far as possible the difficulties encountered when using this type of connector in rack mounting applications, they have greater latitude in matching up than any comparable product, and are in use throughout the world in Radio, Television and Telecommunications equipment by such renowned firms as:— Messrs. Marconi's Wireless Telegraph Co. Ltd., The English Electric Co. Ltd. and Messrs. Standard Telephones & Cables Ltd.

A.I.D & A.R.B – APPROVED

POWER CONTROLS

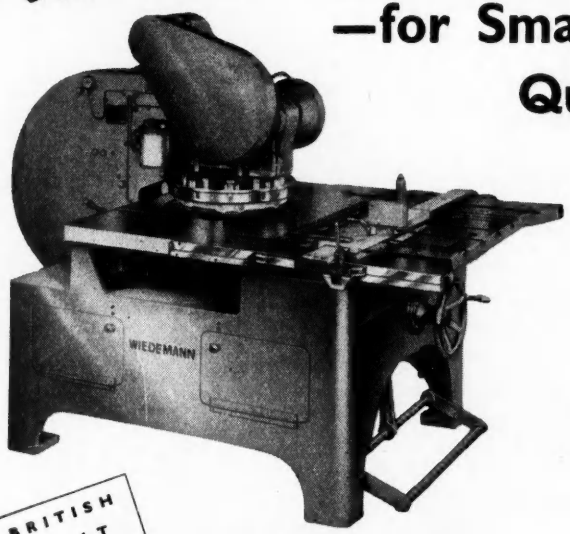
LIMITED

EXNING RD., NEWMARKET

PHONE: NEW 3181/2/3

Fastest Piercing

—for Smaller Production Quantities



BRITISH BUILT

WIEDEMANN

Type RA-41P

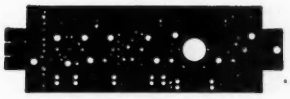
TURRET PUNCH PRESSES

give lower production costs
—than by any other method

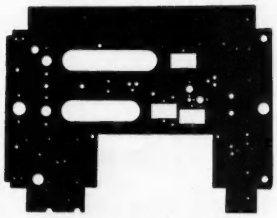
The RA-41P combines the versatility, accuracy and high speed of the pantograph for rapid hole location, with the time saving features of the WIEDEMANN Turret Punch Press for quick punch and die selection. Up to 20 low cost punches can be set up in the turret ready for instant use.

Maximum sheet size	28 in. x 40 in.
Throat depth	28 in.
Capacity	15 tons
Punching Capacity ...	3" diameter in .074" thick Mild Steel
	2" " " $\frac{1}{2}$" " " "
	$1\frac{3}{16}$" " " $\frac{3}{16}$" " " "
Strokes per minute	175

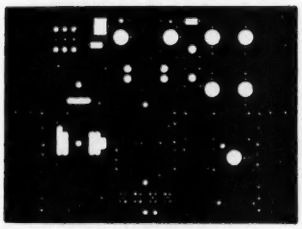
SHEET AREA UP TO 28" x 40"



OUTPUT—18 PER HOUR



OUTPUT—15 PER HOUR



OUTPUT—10 PER HOUR

ALL OPENINGS PIERCED IN TIMES SHOWN

The WIEDEMANN range includes small hand-operated models up to large power-operated machines of 80 tons capacity, capable of piercing 6" holes in $\frac{1}{4}$" plate.

Write to Sales Department for detailed Catalogue

DOWDING & DOLL LTD

346 KENSINGTON HIGH STREET, LONDON, W. 14

Telephone **WESTERN 8077 (8 lines)** *Telegrams:* **ACCURATOOL HAMMER LONDON**

58

TIME *to change . . .*

. . . to a really first-class new instrument which is now offered to research and development workers. The New Nagard Oscilloscopes represent years of accumulated experience in this field. The instruments illustrated show two extremes of a wide range of Oscilloscopes employing so many advances in design and construction that a completely new standard has been reached.

MODEL M201

For **High Speed Transients** or pulses—single stroke to 20 Kc/s p.r.f.

Sweep speed up to 25 cms/μsec on 6″ CRT.

Calibrated time measurement plus sweep expansion × 5.

D.C. Y Amplifier—0.02 μsec **rise time** critically damped—sine wave response 0—25 Mc/s. High impedance input and built-in delay line.

Input voltage calibration from 0.2 to 120 v. or to 6000v. via high voltage attenuator.

Sensitivity 5 mm/volt peak to peak.

Unit Construction—rugged, accessible and mobile.

MODEL DS103

A Double Gun D.C. Oscilloscope of great versatility at modest cost.

Wide Range Time Base with extra slow speed range continuously variable from 2 sec/cm to 20 μsec/cm on 6″ CRT. Independent X shift on each beam.

Sweep expansion × 5 on either or both beams.

D.C. X Amplifier incorporated

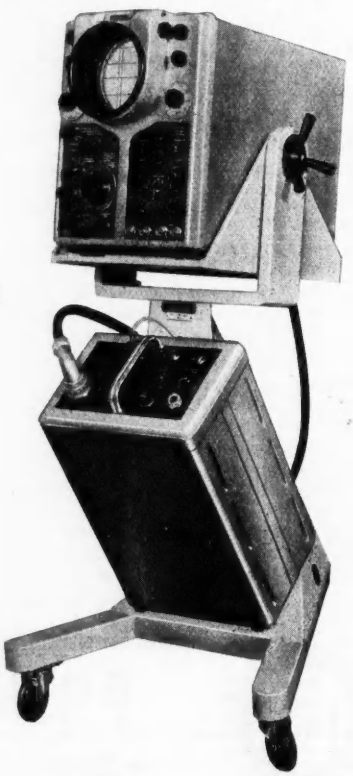
Dual Channel D.C. Y Amplifier—0—200 Kc/s (—3dB) Identical conditions for each gun system provide—

Balanced high discrimination inputs,

Voltage Measurement to 5% from 10 mV to 500v

Sensitivity 8 mV/cm peak/peak or with Nagard Pre-Amplifier type 2701, signals down to 20 μV.

NAGARD LTD



NAGARD LTD. · 18 AVENUE ROAD · BELMONT · SURREY · VIGilant 0345

SenTerCel H.T. rectifiers

from 125V 30mA
to 250V 300mA

Specially designed for use in domestic Radio & Television receivers, these miniature rectifier stacks have an established position with manufacturers to whom reliability, small dimensions and low costs are important.

FEATURES

- Instant starting — no warming-up period
- Unlimited instantaneous overload
- No limit to size of reservoir capacitor
- Simple mounting—no valve holder
- Withstand overloads such as charging current of de-formed electrolytic capacitors
- Low heat dissipation
- Practically indestructible in service
- Simple wiring—two connectors only
- Small size . . . low weight
- Low cost

TYPE	RM0	RM1	RM2	RM3	RM4	*RM5
Maximum ambient temperature	35°C 55°C	35°C 55°C	35°C 55°C	35°C 55°C	40°C 55°C	40°C 55°C
Maximum output current (mean)	30mA 15mA	60mA 30mA	100mA 60mA	120mA 90mA	250mA 125mA	300mA 150mA
Maximum input voltage (r.m.s.)	125V	125V	125V	125V	250V	250V
Maximum peak inverse voltage	350V	350V	350V	350V	700V	700V
Max. instantaneous peak current	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited	Unlimited
Weight	0.82 oz.	1 oz.	1.4 oz.	2 oz.	4.5 oz.	4.75 oz.

*For use in voltage doubler circuits the peak inverse and maximum input voltages are halved, current output being as for half wave operation.

SELENIUM SenTerCel RECTIFIERS

Standard Telephones and Cables Limited

Registered Office: Connaught House, Aldwych, London, W.C.2

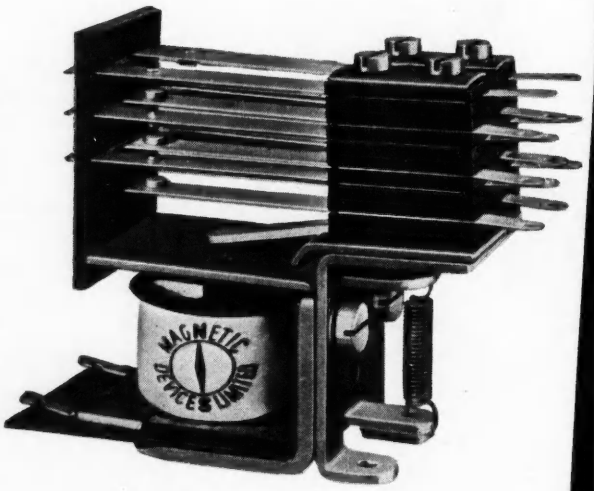
RECTIFIER DIVISION: Warwick Road, Boreham Wood, Hertfordshire. *Telephone: Elstree 2401*

RELAYS

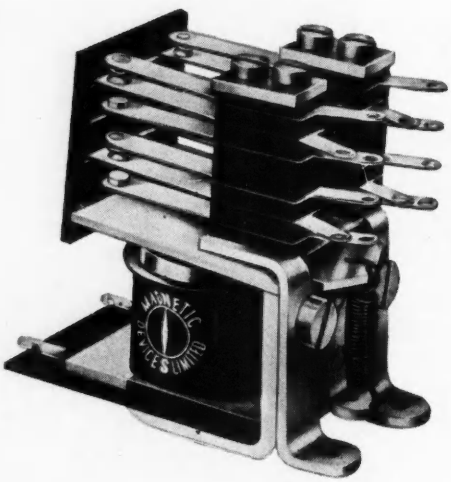
TWO GENERAL PURPOSE TYPES

SERIES 100
A.C. OPERATED

SERIES 105
D.C. OPERATED



An extremely sturdy general purpose relay, which is available in a range of contact combinations from 1 pole normally open to 4 pole changeover, and 6 pole normally open, with a maximum contact rating of 10 amps 250v A.C. Normal power consumption is 3 watts, which can be reduced for the smaller contact assemblies if required. Vacuum impregnated coils can be supplied for tropical or humid conditions.



SERIES 600
A.C. OPERATED

SERIES 605
D.C. OPERATED

This relay is similar to the Series 100/105 and has been specifically designed for light duty applications. Featuring sturdy and extremely compact blade assemblies from 1 pole normally open to 4 pole changeover, and 6 pole normally open. The contacts will carry 5 amps at 250v A.C. Following the usual practice all contact connections are conveniently grouped at one end, and coils can be wound for either current or voltage operation to requirement. Vacuum impregnated coils if specified.

PHONE: NEWMARKET 3181-2-3. TELEGRAMS: MAGNETIC NEWMARKET.

MAGNETIC DEVICES LTD
NEWMARKET

M.D.2A

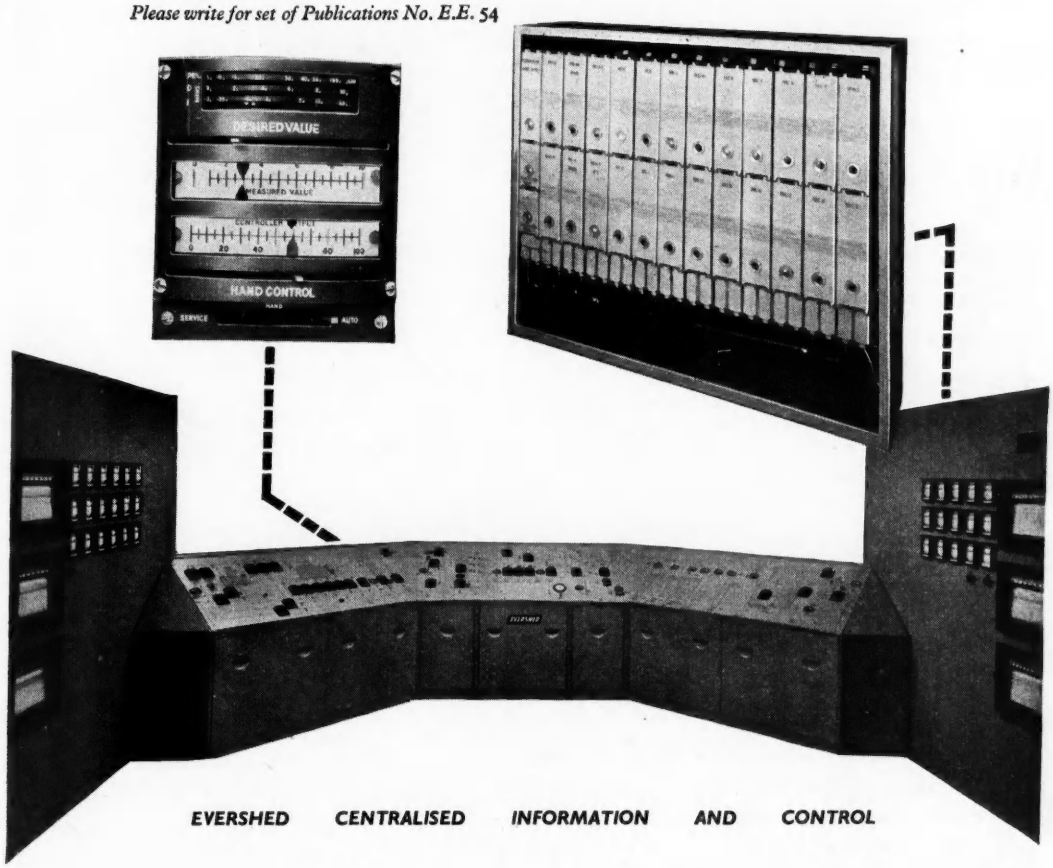
EVERSHED ELECTRONIC CONTROL

at Aden Refinery

Flow, pressure, level and temperature in two 60,000 B.P.S.D. Crude Distillation Units are automatically controlled from two Central Control Desks at the new Anglo-Iranian Refinery.

The process is illustrated on the desk by a coloured mimic diagram with indicators and controller adjustments mounted at appropriate points in the diagram, whilst the controllers themselves are mounted in banks in the wings of each desk. These controllers are connected by cables to the controller adjustments (Miniplaques). Each Miniplaque includes proportional, integral, derivative and desired value adjustments, also indication of measured value and controller output, together with hand-auto and service position controls.

Please write for set of Publications No. E.E. 54



EVERSHED CENTRALISED INFORMATION AND CONTROL

EVERSHED

EVERSHED AND VIGNOLES LIMITED

ACTON LANE WORKS · CHISWICK · LONDON · W4

Telephone: Chiswick 3670 · Cables: Megger, London · Telegrams: Megger, Chisk, London

G 142

The *NEW* Muirhead-Wigan decade oscillator

TYPE D-650-A

THIS precision laboratory oscillator, which covers a range of 1 to 111,100c/s with an overall frequency accuracy of ±0.2% or ±0.5c/s, employs the decade tuning system, by means of which the frequency can be set quickly and accurately on four decade dials and a range switch. This system of tuning ensures the highest possible frequency accuracy and stability. It also enables a given frequency setting to be repeated exactly, and permits the addition or subtraction of a fixed number of cycles per second, thus giving an incremental accuracy of an extremely high order. No other type of oscillator possesses all these advantages.

FEATURES

Frequency range: 1-11,110c/s and 10-111,100c/s.

Frequency accuracy: ±0.2% or ±0.5c/s.

Hourly frequency stability: ±0.02% over most of range.

Maximum output:
2W into 8000 ohms above 20c/s.
50mW into 8000 ohms below 20c/s.

Harmonic content: 1% at 1W output.

Hum level: —80db relative to maximum output at 1000c/s.

Power supply: 200-250V, 50c/s; 90W. or 95-125V, 60c/s; 90W.

Dimensions: 17¼ in. wide x 10½ in. high x 13 in. deep. (43·8 cm x 26·7 cm x 33 cm).

Weight: 83 lb. (38 kg).

MAIL THIS COUPON FOR DESCRIPTIVE BROCHURE

NAME_____

POSITION_____

COMPANY_____

ADDRESS to which BROCHURE should be sent

_____

_____

114

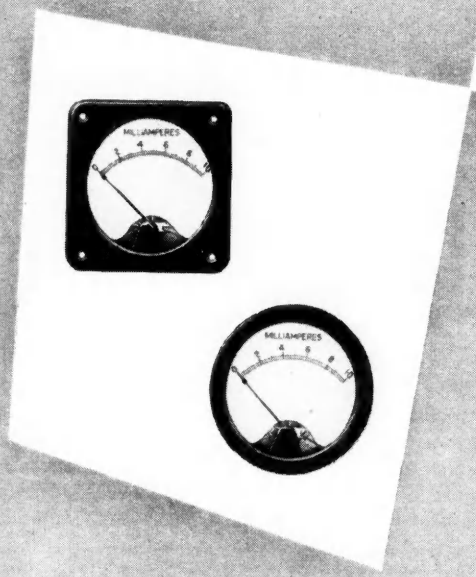
MUIRHEAD & CO. LIMITED · BECKENHAM · KENT · ENGLAND

FERRANTI

CATHODE RAY TUBES

A wide range of Cathode Ray Tubes and Valves for industrial and domestic use is manufactured by the Electronics Department. 14″ and 17″ Rectangular Tetrode Cathode Ray Tubes with Aluminized screens and 6·3 volt, 0·3 amp. heaters are available.

Enquiries to Electronics Dept., Moston, Manchester, 10.



SMALL HERMETICALLY SEALED INSTRUMENTS

Ferranti 2″, 2½″ and 3½″ Hermetically Sealed Instruments for Service requirements are available in both moving coil and moving iron types for current and voltage measurement.

Enquiries to Instrument Sales Dept., Moston, Manchester, 10.

FERRANTI

FERRANTI LTD · MOSTON · MANCHESTER 10

Head Office and Works: HOLLINWOOD · LANCS

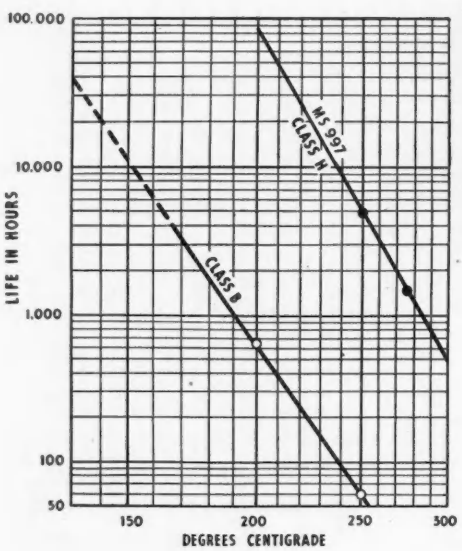
London Office: KERN HOUSE, 36 KINGSWAY, W.C.2.

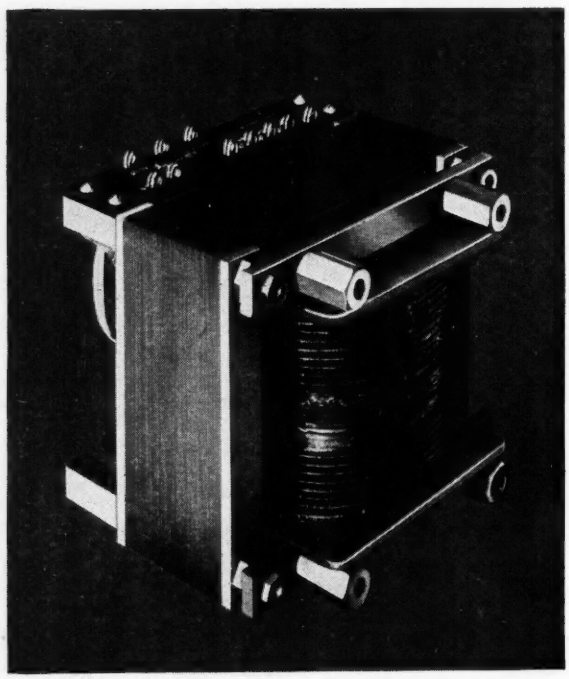
FG 179

SILICONE INSULATION

in electronic equipment

Silicone-bonded insulation includes resin-bonded glasscloth laminates in rod, tube and sheet form that can be machined and fabricated; varnished glasscloth from 0.004in. thick; micanite and mica/glasscloth; varnished glasscloth and silicone rubber sleevings and silicone-enamelled winding wire. Coils are impregnated with silicone varnish MS997. Silicone insulation will withstand operating temperatures at least 50°C. higher than conventional insulation. Where extreme compactness of design is necessary, particularly if excessive temperature rises are likely, silicone insulation is recommended.





A recent, typical example of a component designed for silicone insulation is the power transformer made by Marconi's Wireless Telegraph Co. Ltd. for use in B.B.C. television cameras. These transformers are insulated with silicone-bonded materials and impregnated with silicone varnish for operation up to 150°C. By using silicone insulation the transformers give more power per pound weight than with any other form of insulation.

THIS GRAPH compares the thermal endurance of silicone varnishes. The "life" is based on the hours necessary to reduce the electric strength of varnished glasscloth to half its initial value. Measurements were made on strips of heat-cleaned 0.004 in. glasscloth. Each strip was dip-coated with the varnish, cured and then dipped and cured again to give a finished thickness of 0.007 ± 0.001 in.

Write for full information to

MIDLAND SILICONES LTD

(An associate company of ALBRIGHT & WILSON LTD.)

19 UPPER BROOK STREET · LONDON · W.1. *(Tel: Grosvenor 4551)*

BRITISH MADE SILICONES

BRITISH MADE SILICONES

TBW/MS36

we manufacture AND STOCK many unusual transformers as regular catalogue lines

TYPE AV 479
Primary
10-0-200-220-240v. 50~
Secondary
4v. 2 amps 10kV R.M.S. Wk.g.

One of 370 standard types in stock for "off-the-shelf" delivery

write for illustrated and fully descriptive catalogue

GARDNERS RADIO Ltd

SOMERFORD, CHRISTCHURCH, HAMPSHIRE

Tel. Christchurch 1024

LEOCAST COMPONENTS AND CIRCUITS

Leocasting is the specialised process of CASTING OR MOULDING IN RESIN of components or sub-circuits. It embraces such terms as 'Potted Circuits,' 'Moulded Circuits' and 'Resin Cast' or 'Resin Encapsulated' Circuits.

Lion Switchgear Ltd. have perfected the process, and will carry out Leocasting on a prototype or production basis using resins specified by customers or will select one of their own special 'mixes' for the particular application.

Ask for the LEOCAST leaflet for fuller details.

The Special Products Department of Lion Switchgear Ltd. is in a position to undertake the manufacture of Electronic Assemblies and Equipments. Prototypes, large batches or short pre-production runs of equipment can be produced to specification. This service includes the fabrication of metalwork, electro-plating, spraying and finishing as well as assembly, wiring and testing. **Ask for the Special Products Leaflet.**

★ EXPORT ENQUIRIES INVITED ★

LION SWITCHGEAR LTD.

ELECTRONICS DIVISION

LION WORKS · HANWORTH TRADING ESTATE
HAMPTON ROAD · FELTHAM · MIDDLESEX

TELEPHONE : FELTHAM 3567 and 2922

Mullard Ferroxcube being extruded into rods for H.F. cores.

MAGNETIC MATERIALS Extensive research and manufacturing facilities have established Mullard as the leading producers of magnetic materials. They were the first, for example, to introduce Ferroxcube, the world's most efficient magnetic ferrite; 'Ticonal' anisotropic permanent magnets, renowned for their high stability and high energy output; and Magnadur, an entirely new type of permanent magnet with the insulating properties of a ceramic.

The wealth of experience gained from these developments is available to all users of magnetic materials through the Mullard advisory service. An enquiry to the address below will put a team of specialised engineers at your disposal.

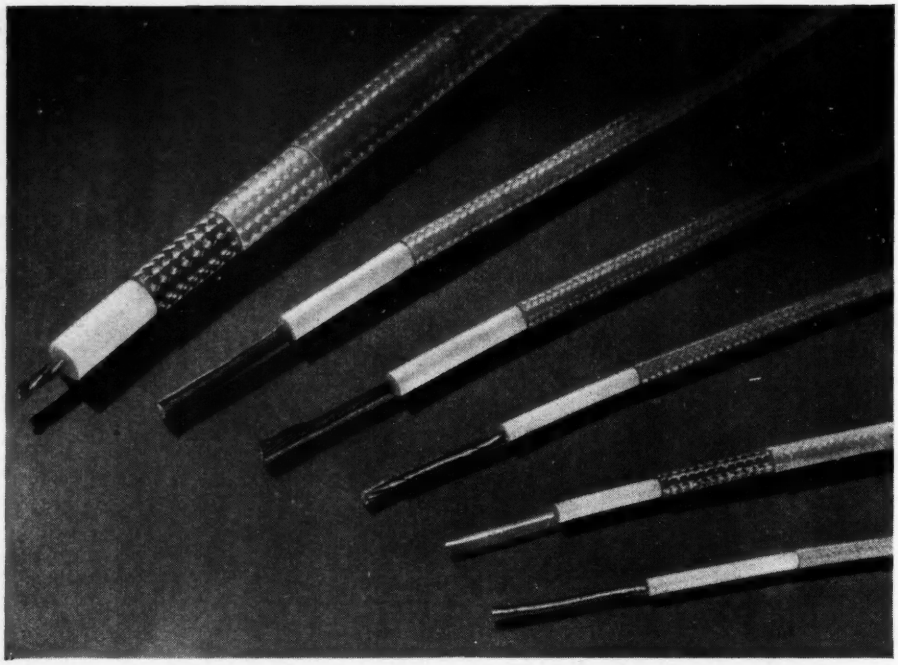
Mullard

Mullard

'TICONAL' PERMANENT MAGNETS · MAGNADUR (Formerly Ferroxdure) PERMANENT MAGNETS · FERROXCUBE MAGNETIC CORE MATERIAL

MULLARD LTD., COMPONENT DIVISION, CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2.

CABLES and CORROSION



'FLUON'-insulated cables made by British Insulated Callender's Cables Limited

'FLUON' ★
holds its insulating and dielectric properties from –75°c. to 250°c.

It is the ONLY material that can be used on high frequency, *high-temperature* cables operating under corrosive conditions.

Power factor	< 0.000 2
Dielectric Constant	2.0
Dielectric Strength	1,500 to 1,800 volts/mil. on .005 in. sheet.
Surface Arc Resistance	> 100 secs. (non-tracking)
Volume Resistivity	10^{19}—10^{21} ohm/cm.
Water Absorption	Nil

Chemically inert, and unattacked by acids, alkalis or solvents. Non-inflammable.

★ *'FLUON' is the registered trade mark of the polytetrafluoroethylene manufactured by I.C.I. Please ask for full technical data.*

ICI

IMPERIAL CHEMICAL INDUSTRIES LTD., LONDON, S.W.1

P.572

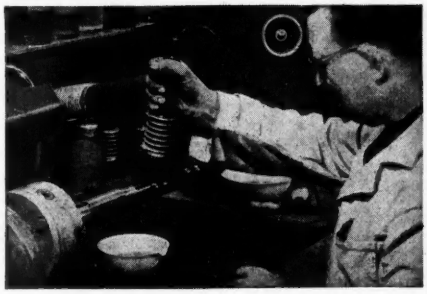
The Dalic Process of Electrodeposition

Renovating the zinc protective coating of a propeller blade on site at Air France.

The DALIC PROCESS of Electrodeposition provides a wide range of coatings on to most basis materials, including aluminium. It is particularly suitable for plating selected areas without stopping-off, for on-site work, and for plating assemblies or components which may not be immersed in plating solutions.

For such non-decorative purposes as building-up worn or overmachined parts, the extremely high speed of deposition and the accuracy with which deposit thickness can be controlled are most attractive features. Deposits are characterised by low stress, extremely fine grain, perfect adhesion and complete absence of porosity.

The DALIC PROCESS has received overwhelming acceptance by industry and recent installations have been made in the electronics, motor car, radio and television and armaments industries, in the Ministry of Supply, and in various research establishments.



Characteristics of Dalic Deposits

Deposit	Maximum Current density (amp./sq. ft.)	Brinell hardness of deposits	Time to deposit 0.0001 in.* (sec.)
Bismuth	1,250	50	7.6
Cadmium	6,000	40	2.5
Chromium	4,000	600	63
Cobalt	1,500	250	7.6
Copper	6,000	150	2.5
Gold	2,000	100	6.2
Indium	4,000	<1	2.5
Iron	3,000	175	10.2
Lead	5,000	20	3.8
Nickel	5,000	500	5.1
Platinum	3,000	200	17.5
Rhodium	3,000	500	70
Silver	1,250	60	5.1
Tin	5,000	1	2.5
Zinc	3,000	70	3.8

** Assuming the pad electrode employed were stationary. Since, in practice, it is moved over the surface being plated, this time should be increased by the area of the surface divided by the area of the pad.*

A practical demonstration at our laboratories will be given without obligation

Sole Licensees for the British Isles

METACHEMICAL PROCESSES LTD.

13, STRAFFORD ROAD · LONDON · W.3 · ACORN 0131/2

Q. What is a DIFFERENCE DIODE

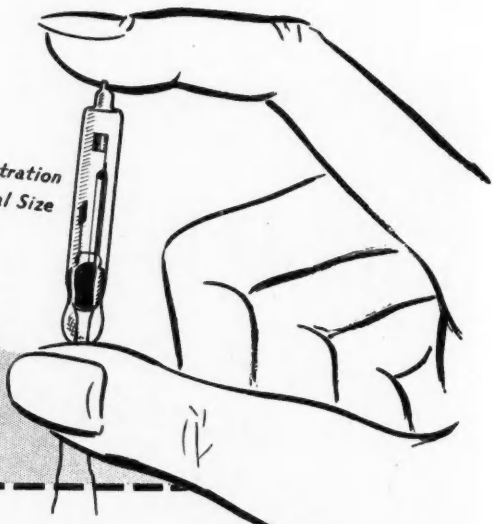


Illustration Actual Size

A. A *DIFFERENCE DIODE* IS A COLD CATHODE DIODE CHARACTERISED BY A LARGE DIFFERENCE BETWEEN THE STRIKING AND MAINTAINING VOLTAGES.

The XC14 *Difference Diode* is the latest sub-miniature cold cathode diode developed by Hivac especially for use in the telecommunications and computer fields. The striking and maintaining voltages are controlled between limits giving a minimum difference of 70V, which makes the XC14 ideal for storing, counting, gating and similar functions in electronic circuits.

HIVAC
THE SCIENTIFIC VALVE
BRITISH MADE

Characteristics of the XC14 ***DIFFERENCE DIODE***

Strike Voltage.....145-170V.
Maintaining Voltage at 0.5mA.....75V maximum.
Maximum continuous current rating.....0.75mA.

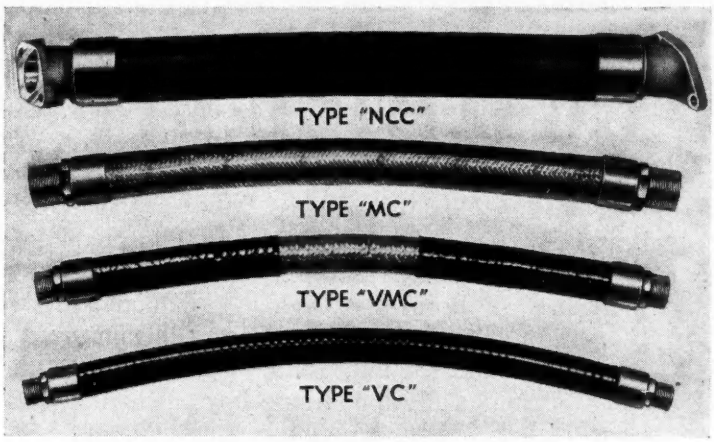
Hivac Limited
STONEFIELD WAY, VICTORIA ROAD, RUISLIP
MIDDLESEX, ENGLAND.
Ruislip 3366 *Cables : Hivac, Ruislip.*

TO INTRODUCE

to you our new range of

WATERPROOF AND OILPROOF

FLEXIBLE ELECTRICAL CONDUITS



As supplied to the Services, and an ever-widening circle of Commercial users.

Something that is "just a bit better".

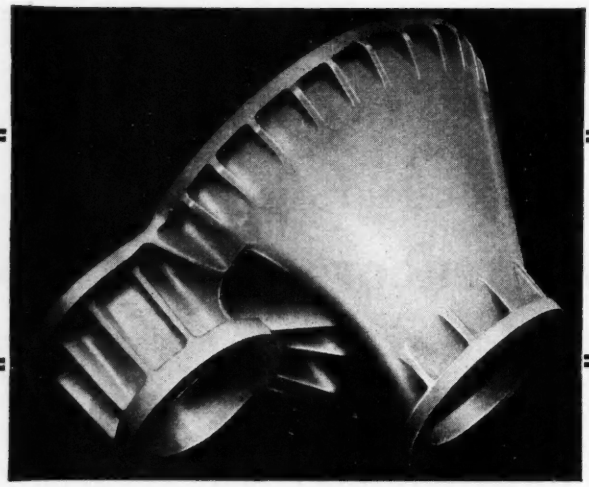
A fully descriptive leaflet will be sent on application.

SUPERFLEXIT

LIMITED

TRADING ESTATE · SLOUGH · BUCKS

Telephone : SLOUGH 24561 (5 lines) *Telegrams* : "FLEXIBLE SLOUGH"



Casting in Aluminium Alloy (approx. weight 208 lbs.)

C.&L.HILL LTD

Manufacturers of

Non-Ferrous Sand Castings, Brass, Naval Brass, Brazing Metal, Gunmetal, Phosphor Bronze, Aluminium Bronze, High Tensile Manganese Bronze, High Conductivity Copper, "Hilchil" Chill Cast Phosphor Bronze Bars, Cored and Solid.
Sand Castings in all Aluminium Alloys, including Heat-treated Alloys, Aluminium Alloy Gravity Die Castings.

Wood and Metal Pattern Shop. Fully Approved Laboratory and Test House with Inspection Organization. Facilities for Radiology.
Specialists in Development and Quantity Production of Castings for Radar.

We solicit your enquiries for
SHELL MOULDED CASTINGS
in all non-ferrous Alloys, including Aluminium

C.&L.HILL LTD

Stringes Lane, Willenhall, S. Staffs.

Tel: Willenhall 227 (4 lines) ***Grams: Hill 227 Willenhall***

Branch Works: Wednesfield Road, Willenhall

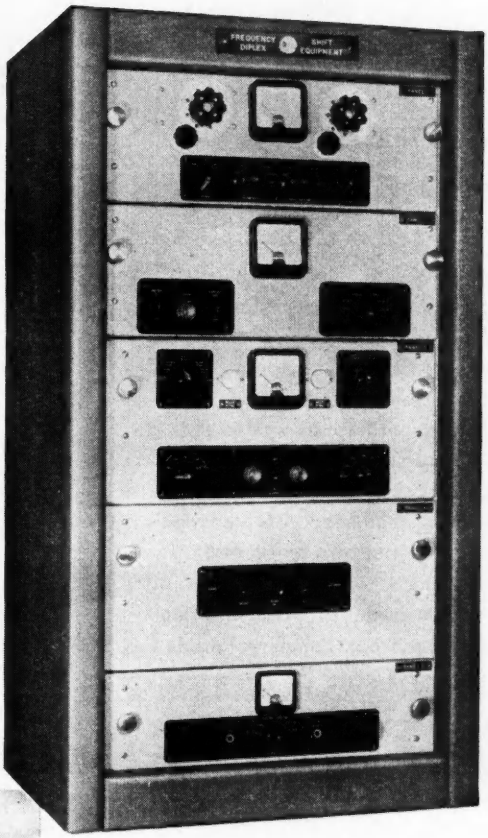
Both our Foundries are available for Prototype Work

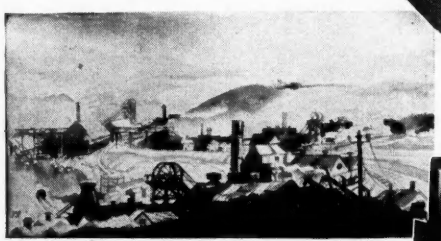
WhiteAd 2619A

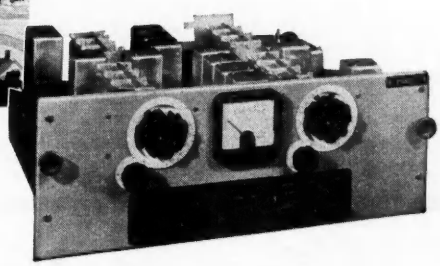
Frequency-Shift Diplex Drive and Keying Equipment

TYPE HD 61

Diplex or twin-channel Frequency-Shift Keying is a development of the single-channel FSK system which has proved its advantages in recent years. Diplex FSK enables two simultaneous frequency-shift telegraph channels to be operated on a single CW transmission. The Type HD 61 equipment illustrated is designed for keying most class C transmitters, including the Marconi S.W.B. series, by the diplex frequency-shift system. It also provide single-channel FSK for telegraphy and on-off keying of CW. Any one of six pre-set crystal controlled frequencies may be instantaneously selected.







The equipment comprises five units (mixer, crystal, keyer, power supply and monitor). Units may be readily removed for replacement or servicing.

MARCONI

COMPLETE COMMUNICATION SYSTEMS

Surveyed, planned, installed, maintained

MARCONI'S WIRELESS TELEGRAPH CO. LTD., CHELMSFORD, ESSEX

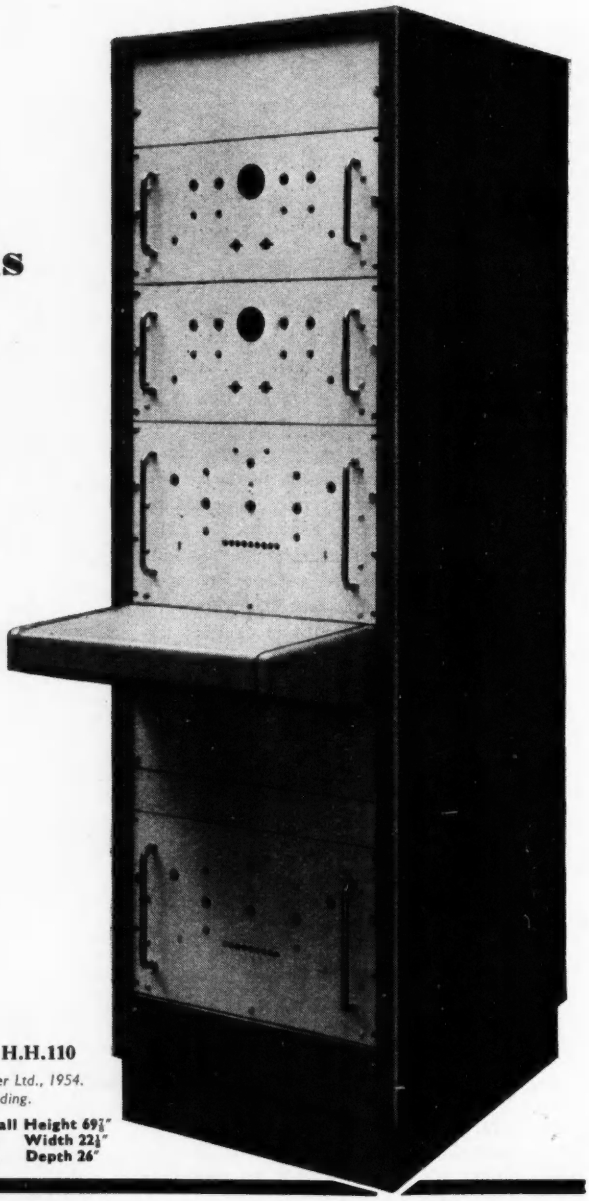
LC4

Electronic Instrument Racks

Your delicate and expensive Electronic Equipment deserves worthy housing. H. H. Cabinets and Racks add, to unique design and precision craftsmanship, the crowning merit of superb finish. Specialists in the production of precision sheet metal work, for many years, we are admirably equipped to provide cabinets to your own specification, at prices which, while allowing for a high standard of craftsmanship throughout, are extremely reasonable.

Our Design and Development Staff is always at your disposal. May we serve you ?

We also manufacture precision components to users' designs :—All types of Valve Screens, Coil Cans, Chassis, Panels, Condenser Mountings, Valve Mountings, Loud Speaker Chassis, and pressings and sub-assemblies in any metal.



H.H.110

Copyright Hassett & Harper Ltd., 1954.
British Patents Pending.

Overall Height 69¾"
,, Width 22½"
,, Depth 26"

Hassett & Harper Ltd

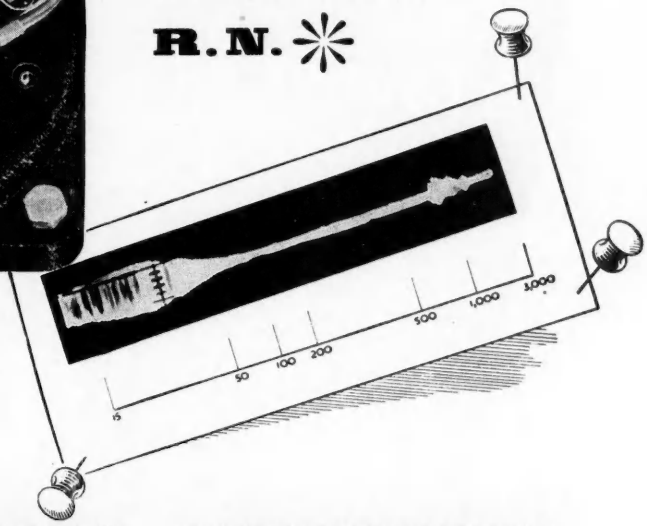
REGENT PLACE, BIRMINGHAM, 1. ***Telephone :*** **CENtral 6418 (4 lines)**

LONDON : 140, PARK LANE, W.1. *Telephone :* MAYfair 9651 (3 lines)

CONTRACTORS TO GOVERNMENT DEPARTMENTS

BRIMAR

Pin down R.N. ✳



Illustrations by courtesy of Standard Telephones and Cables Limited who say, "These vibrators have been chosen as they give a faithful reproduction of the input wave form and enable high accelerations at any frequency to be obtained."

with GOODMANS VIBRATORS

✳ RESONANCE NOISE describes a particular factor in a valve which can very seriously impair its otherwise good characteristics. Only when "R.N." is negligible can a valve operate strictly according to its published 'curve' and data.

Complete investigation of this phenomenon is only possible by subjecting the valve to *controlled* vibration throughout a wide frequency range. If the valve is operated in a Class A circuit, and the A.C. noise voltage appearing at the anode of the valve is presented on an oscilloscope, a resonance diagram against input frequency can be obtained. By this means it is possible to excite the valve in the range of frequencies 20 to 10,000 c/s, and the resonance noise performance checked. By the use of a twin mounting as illustrated, comparison of valves can be made under identical conditions.

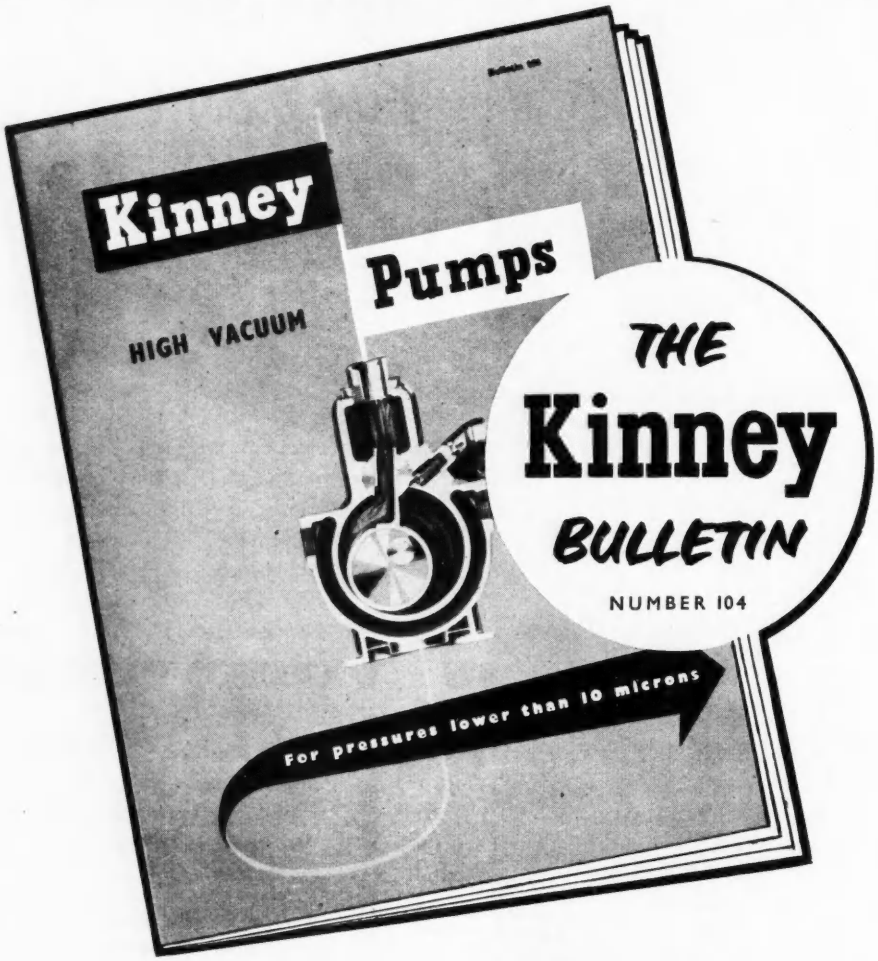
Just another of the wide applications of Goodmans Vibration Generators. Perhaps "controlled vibration" can serve you also.

The range includes models developing a force of ± 300 lbs. to the midget model with a force output of ±2lbs. for optical-cell research and hairspring torque testing, etc. Full technical data available from "Vibration Division Y"

GOODMANS INDUSTRIES LIMITED,
Axiom Works, Wembley, Middlesex.
'Phone: Wembley 1200 (8 lines).

GD

AVAILABLE TO YOU NOW FREE!



6 PAGES OF SOUND TECHNICAL ADVICE ABOUT KINNEY VACUUM PUMPS

If you manufacture products like electric lamps, coated lenses, mirrors, C.R. tubes, foodstuffs, drugs and coated foils, then Bulletin 104 has been printed for you. Here is a wealth of detail describing and illustrating Kinney High Vacuum Pumps—how they work, quoting dimensions, speeds and performance curves. Everything, in short, to demonstrate how indispensable Kinney Pumps are for up to date production processing. Bulletin 104 cannot fail to be of interest and (we sincerely believe!) profit. Pin this ad. to your note heading. We'll be glad to mail you by return.

GENERAL ENGINEERING CO. (RADCLIFFE) LTD.

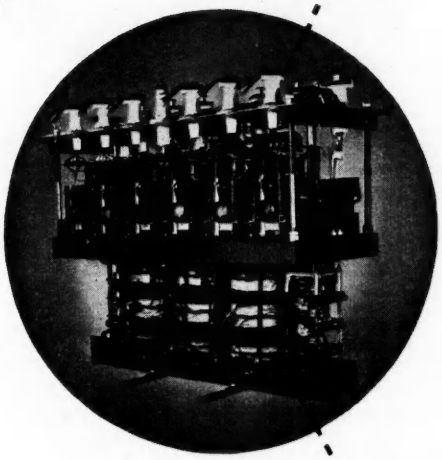
Station Works, Bury Road, Radcliffe, Lancs.

Telephone: RADcliffe 2291 (3 lines) Telegrams: "General" Radcliffe
London Office: 3rd Floor, 9 Victoria Street, London, S.W.1
Telephone: Abbey 5278

TRANSFORMER PROBLEMS WE HAVE SOLVED...

B. B. C. WENVOE
TELEVISION TRANSMITTER

At Wenvoe (as also at Kirk o' Shotts) Gresham Transformers were specified for both the sound and vision transmitters to meet the demand for utmost reliability and efficiency. The Gresham Transformer unit supplying power to the sound transmitter consists of 25 transformers and chokes compactly assembled in one tank.



Gresham Transformers Ltd. are Specialist Designers and Manufacturers who have progressively established and sustained a reputation for producing the most reliable transformers in Britain. Ranging in size from miniature electronic types to power distribution transformers up to 1500 kVA, 33000V their products are in constant demand in the fields of Radio, Electronics, Industry and Power Supply.

To Every Transformer Problem There is a GRESHAM *Answer*

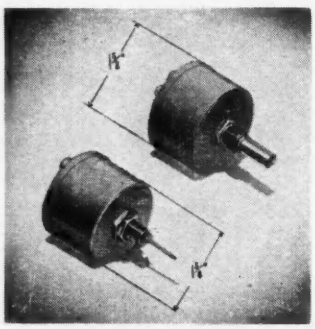
HANWORTH **GRESHAM TRANSFORMERS LTD** MIDDLESEX

TWICKENHAM ROAD, HANWORTH, MIDDLESEX. FELtham 2271-4

TOROIDAL POTENTIOMETERS

If you would like full details of our range of Toroidal High Precision, Helical and Heavy Duty Ceramic Potentiometers, send for our newly-published Catalogue No. 102.

Ceramic Insulation only — and approved for Tropical conditions. Complete Ceramic Rings for strength. Approved by all Government Departments. Also precision Toroidal-wound Potentiometers (including 360° of winding with up to eight tapping points) and Helical wound Potentiometers of 3600° of winding. All are available with sealed spindles and glass or ceramic terminal seats.



PRECISION POTENTIOMETERS

TYPE G. (Low Torque Miniature)

SPECIFICATIONS

Rating—1 Watt
Resistance Range—500 ohms to 50,000 ohms.
Winding—Nickel/Copper and Nickel/Chrome Wires.
Effective Angle of Winding—300° or as Specified.
Overall Resistance Tolerance—±5%
Linear Accuracy—within 0·5% or as specified.
Angle of Rotation—Continuous Rotation—no Stops.
Operating Torque—0·01 ozs/inch (0·78 gram/cm).

Similar model of smaller dimensions Type F. also available—Operating Torque for Type F. is 0·005 ozs/inch (0·35 gram/cm).

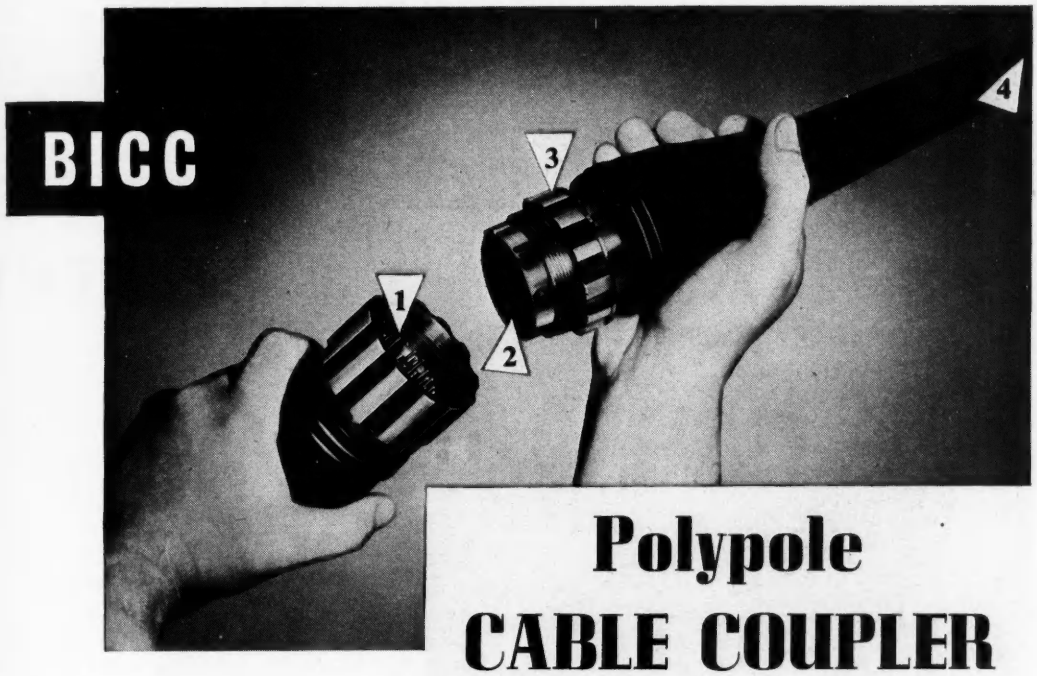
Thanks to extensive re-organisation, we can now give good delivery of all types of potentiometers

P · X · FOX LTD · HAWKSWORTH RD · HORSFORTH · YORKSHIRE

Telephone: Horsforth 2831/2 *Telegrams: Toroidal, Leeds*

P·X·F

ndk2945



Polypole CABLE COUPLER

For- ***specialised remote control—centimetre radio links—ground radar—outside broadcast television***

BICC Couplers and Cables are intended for the outdoor inter-connection of equipment, such as that mentioned above. Each application calls for composite trailing cables containing both R.F. units and other polythene insulated conductors.

BICC Polypole Mark III Couplers are available in two versions, designed for use with two standard types of BICC outdoor trailing cables. The Mark IIIA cable and coupler incorporates three coaxial circuits, and the Mark IIIB three screened twin circuits. In addition, both cables contain three triplets and 21 other conductors.

The couplers are permanently moulded to the ends of the cable in the factory. This technique provides a remarkably robust coupler which is virtually free from the hazards of conductor breakages near to, or within the coupler.

If you are interested in the uses of BICC Polypole Cable Couplers, we will be pleased to send you further information.

Note these important features

1 The couplers are assembled with the conductors in tension to ensure that they each contribute their share of the total strength.

2 Polythene injection moulding permits a watertight assembly.

3 Screwed lock rings provide forced engagement and withdrawal. The overall metal housing can also be easily replaced should it become damaged.

4 The cable itself is designed with a symmetrical cross section to provide the greatest reliability under severe handling.

BI Callender's

BRITISH INSULATED CALLENDER'S CABLES LIMITED
21, BLOOMSBURY STREET, LONDON, W.C.1.

CATHODE FOLLOWER UNIT

Type C.F.1

The Cathode Follower Unit C.F.1 has been designed for connection between high-impedance pickups such as piezo-electric accelerometers, crystals and quartz load cells, but could be used to advantage when detecting signals in electronic circuitry where parallel loading is undesirable. Outstanding features of the unit are its compactness and its freedom from microphony: signal amplitudes of 10 microvolts may be relayed without interference.

Full details on request from:—

J. LANGHAM THOMPSON LTD.

BUSHEY HEATH · HERTS.

Telephone: Bushey Heath 2411 · Grams and Cables: "Tommy Watford"

35 mm. OSCILLOSCOPE CAMERA

for single shot operation

- Daylight loading
- Viewing of screen whilst recording
- Lenses from f/3.5 - f/1
- Indication of remaining exposures
- Adaptation to popular oscilloscopes
- Shirley-Wellard cassettes
- Manual shutter operation for beam switching

ELECTRONICS
EXHIBITION
•
MANCHESTER
July 14th — 20th

Full details on request from :—

J. LANGHAM THOMPSON LTD.

BUSHEY HEATH · HERTS.

Telephone : Bushey Heath 2411 · Grams and Cables : "Tommy Watford"

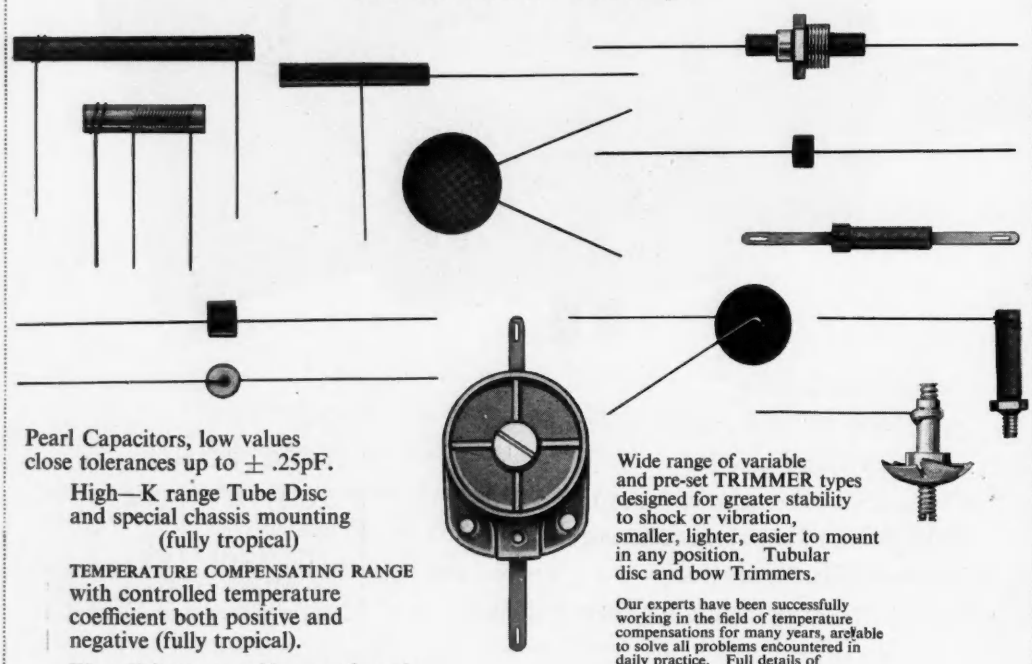
ST
CON

Improve your products with our Capacitors and Trimmers

Closer tolerances — More values to choose from

*Our modern engineered ceramics are a **new** answer to old design problems*

By the application of new DIELECTRIC ceramics and production technique our CERAMIC CAPACITORS have set a new standard of excellence. Built to meet the most exacting requirements of today's Radio-Television and Electronic Industry.



Pearl Capacitors, low values close tolerances up to ± .25pF.

High—K range Tube Disc and special chassis mounting (fully tropical)

TEMPERATURE COMPENSATING RANGE with controlled temperature coefficient both positive and negative (fully tropical).

We solicit your problems and needs

Wide range of variable and pre-set TRIMMER types designed for greater stability to shock or vibration, smaller, lighter, easier to mount in any position. Tubular disc and bow Trimmers.

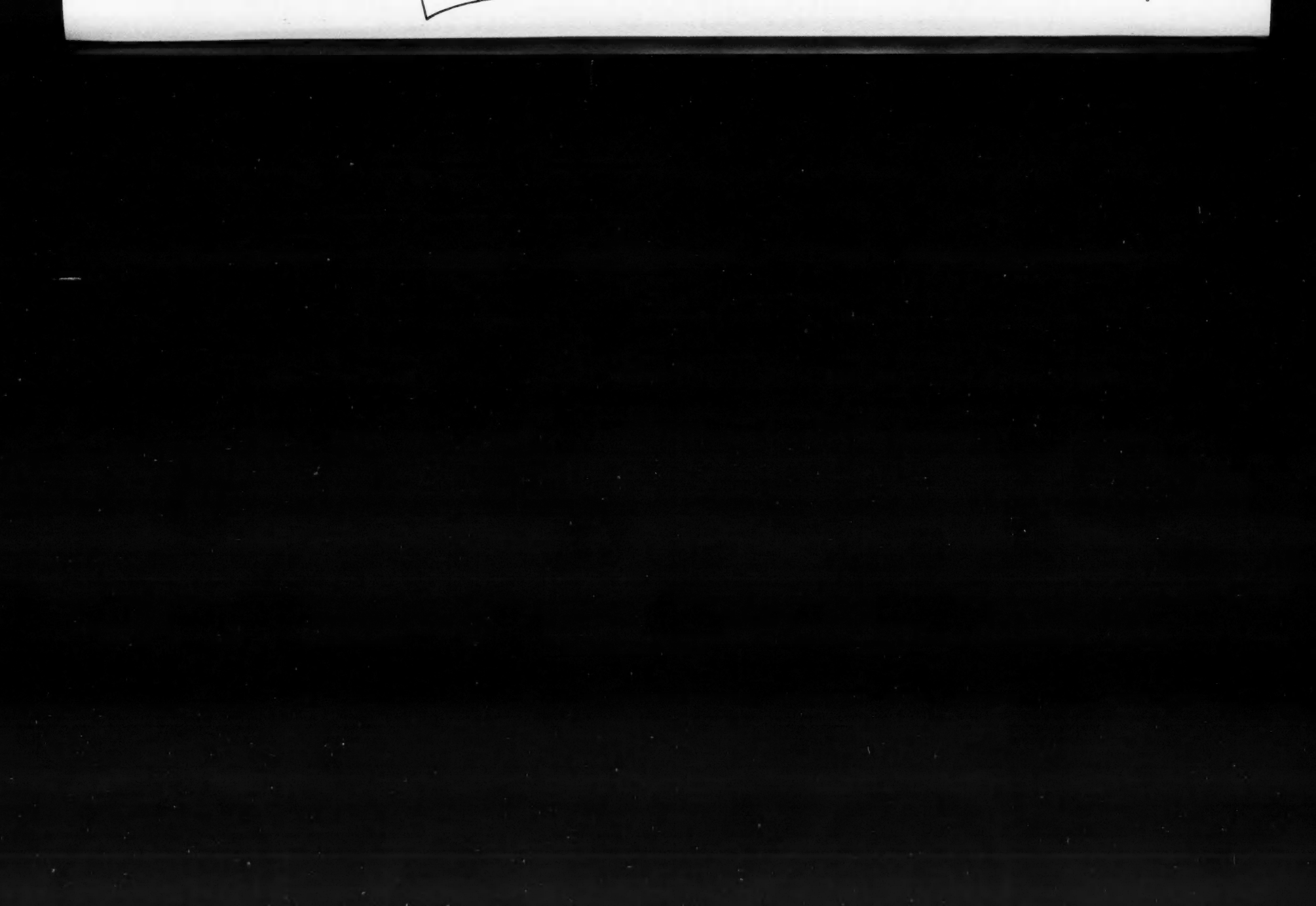
Our experts have been successfully working in the field of temperature compensations for many years, are able to solve all problems encountered in daily practice. Full details of capacitors available on application.

STEATITE INSULATIONS LTD.

25 SOMERSET ROAD, EDGBASTON, BIRMINGHAM, 15.

Tel. EDGbaston 3990

Tel. Add. " STEATITE - BIRMINGHAM, 15 "



Spring Quiz
No. 6

what is
the Limit of Proportionality?

This is the point where stress and strain cease to have a linear relationship, a point which, if exceeded, means permanent deformation.

We make good-tempered springs !

F.S. Ratcliffe
(ROCHDALE) LIMITED
THE SPRING SPECIALIST

REGISTERED RECOIL TRADE MARK

Phone: Rochdale 4692/3 Grams: Recoil, Rochdale

CRAWFORD SPRING WORKS, ROCHDALE, LANCS

Electronic Engineering

Incorporating ELECTRONICS, TELEVISION and SHORT WAVE WORLD.
Managing Editor H. G. Foster, M.Sc., M.I.E.E.

Vol. XXVI JULY 1954 No. 317

Contents

Commentary	283
LEO Lyons' Electronic Office — By J. M. M. Pinkerton and E. J. Kaye	284
A New Impedance Matching Arrangement	291
Recording Television and Sound Signals on Magnetic Tape	292
New Television Relay Cable	295
The Zinc Coating of Paper for Capacitors by Vacuum Evaporation — By L. Holland and K. Hacking	296
More About Circuits and Logic — By T. L. Craven	302
Q as a Mathematical Parameter — By David Morris	306
Multi-Channel Counter Batching — By P. Huggins	308
A.C. Voltage Stabilizers — By W. M. Dalton	310
The Measurement of Transistor Characteristics — By J. Ewels	313
The Driven Clamp in the Presence of Noise — By P. B. Helsdon	315
A Simplified Circuit and Conductimetric Tube for Chemical Analysis at Low-Frequency — By G. G. Blake	316
Oscillator Feedback Networks — By P. W. Ward	318
Colour Television	320
Short News Items	321
Letters to the Editor	322
Electronic Equipment	324
Book Reviews	326

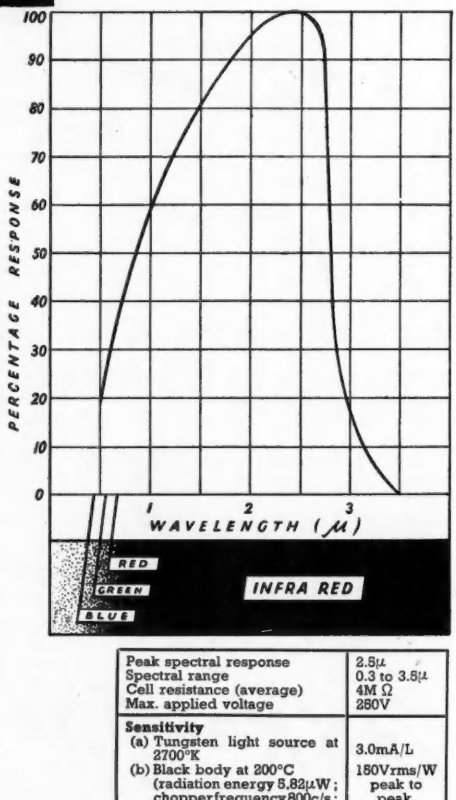
Published Monthly on the last Friday of the preceding month at 28 Essex Street, Strand, London, W.C.2.

Telephone: CENTRAL 6565
Telegrams: 'LECTRONING, ESTRAND, LONDON'

Subscription Rate:
(Home or Abroad) Post Paid 12 months 26s. or $3.75 (U.S.)

Classified Advertisements, Page 1
Index to ADVERTISERS, 117 and 118

61SV EXTRA SENSITIVE lead sulphide photoconductive cell



A NEW CONTRIBUTION TO

***INFRA-RED** PRACTICE*

Sensitivity of an unusually high order is one of the features which distinguishes the performance of the Mullard 61SV lead sulphide photoconductive cell. The colour response is peaked at about 2.5 microns — well within the infra-red region — and high sensitivity is extended beyond the usual limits of infra-red detectors to the red end of the visible spectrum. Extremely fast response, which is a unique characteristic of lead sulphide cells is exemplified by the 61SV's performance. Signal-to-noise ratio is high and facilitates the measurement of very small temperature variations of relatively low temperature sources down to 100°C.

The 61SV is also admirably suited for on/off systems such as infra-red alarms. An example of this type of application is the monitoring of gas, oil-fired and pulverised fuel furnaces where the parameter of principal interest is the heat radiated from the flame rather than its luminous output, and where reliability and rapidity of detector response are essential.

The photoconductive characteristics, small size and rugged construction of the 61SV qualify it for the majority of infra red applications in industry. If you require further information and technical data on this or any other Mullard photocell your enquiry will be welcomed at the address below.

Peak spectral response	2.5μ
Spectral range	0.3 to 3.5μ
Cell resistance (average)	4M Ω
Max. applied voltage	250V
Sensitivity	
(a) Tungsten light source at 2700°K	3.0mA/L
(b) Black body at 200°C (radiation energy 5.82μW; chopper frequency 800c/s; amplifier bandwidth 50c/s)	150Vrms/W peak to peak.

Mullard **61SV**

INFRA-RED PHOTOMETRY
LOW TEMPERATURE PYROMETRY
SPECTROSCOPY
CONTROL IN INDUSTRY
INFRA-RED ALARMS

MULLARD LTD., COMMUNICATIONS & INDUSTRIAL VALVE DEPT., CENTURY HOUSE, SHAFTESBURY AVENUE, LONDON, W.C.2

MVT156

ELECTRONIC ENGINEERING

VOL. XXVI No. 317

JULY 1954

Commentary

TELEVISION has had, during the last month or so, an unusual amount of publicity. The Commercial Television Bill has passed through its committee stages in the House of Commons ; the greatest international link-up so far attempted has been carried out ; a demonstration of colour adapted to British 405 line standards has been given in London.

The committee stage of the Television Bill has been somewhat slow and tortuous with a final curtailment after only nine clauses had been debated. But, although this may interest us as citizens, our only concern as engineers, is in the technical problems involved, and it is already apparent that most manufacturers are ready for operation in the higher frequency bands. A number of receivers are on the market completely equipped for the additional frequency bands, while others are available constructed in such a way that an adapter unit or tuning unit can easily be fitted. This type of multi-band receiver will doubtless be the main theme of the Radio Show at Earls Court in September.

The international exchange of programmes during the past month has been on an unprecedented scale and has involved a number of notable engineering achievements. Some of the major problems, such as the conversion of the different scanning frequencies, had already been solved and tested on previous international relays of which the transmission of pictures of the Coronation ceremonies was previously the most ambitious. In the present exchange the programme and technical resources of eight countries have been pooled. Between Rome and Belfast, the most distant points in the circuit, the signals have to travel no less than 2 000 miles via radio and cable links. It is gratifying to see that a very considerable amount of British manufactured equipment is being used at numerous parts of the link. This is true of, from the engineering viewpoint, perhaps the most spectacular part of the network, the microwave link across the Alps. It runs from Chasseral in Northern Switzerland, 5 000ft high in the Jura range, through a relay station 60 miles away and 12 000ft up on the Jungfraujoch and on to the summit of Monte Generoso in Southern Switzerland. This link, which will remain as a permanent installation, will connect the German and Italian television systems and will form part of the Swiss national network. Altogether some 80 relay stations with convertor units for four different line frequencies will be used, feeding 46 transmitters covering a total population of around 90 millions. This is a meritorious achievement both from the organizational and technical viewpoints and should pave the way for a permanent network and interchange of programmes in the fairly near future—a thing which could, and should, bring about a better understanding between the participating nations.

The demonstration of colour television was given by Marconi's Wireless Telegraph Co. Ltd., and is briefly described elsewhere in this issue. From this demonstration it is apparent that on the present 3Mc/s bandwidth allocation it is, to say the least, difficult to provide a fully compatible picture ; the picture received on a monochrome receiver being degraded rather more than would probably be acceptable to the average viewer. With an increase of some 50 per cent in the bandwidth an excellent degree of compatibility can be achieved. For channels IV and V this would present no problem as the T.A.C. have already proposed a channel width of 7·5Mc/s. However, apart from the considerations of bandwidth and the BBC's pledge to give 97 per cent national coverage in monochrome before the introduction of colour, the major technical problem is still the production of a colour cathode-ray tube at a price that would be acceptable to the general public. This still seems to be a good way off both here and in America.

Looking at these various activities collectively stresses the great difficulty of wise long-term planning in a sphere where development is taking place so rapidly. As pointed out in this journal a few months ago, it was a courageous decision at the time to decide on the development of the 405 line standard in this country ; but now only a few years later we have, theoretically, the lowest standard of definition in Europe. Looked at from another angle it is, without doubt, unfortunate that an international or at least an inter-European agreement could not have been reached on standards of definition, etc., so that programmes could have been exchanged without the need for all the convertors now necessitated. At the end of the last war this may have been possible but now, with so many receivers in use, it would be a formidable task to alter the standards in any one country. Great attention should, however, be given to the problems involved in international exchange before colour television progresses too far and, if possible, before the use of Bands IV and V become widespread.

* * *

HUMAN RELATIONS in Industry is the title of an interesting report that has been issued jointly by the Department of Scientific and Industrial Research and the Medical Research Council. This report outlines the first year's work of the committee set up in March 1953 to co-ordinate and sponsor research work on human relations in industry with particular reference to their influence on productivity. The bulk of the finance for these projects comes from American conditional aid funds. The main job during the year has been the building up of a research programme, and out of 78 projects considered, twelve have already been approved plus another two to be financed by U.K. funds as they do not satisfy the criteria for conditional aid. While all the projects are of as much interest to our industry as to any other, there are several which are of especial interest from the engineering viewpoint. Among these are, " factors facilitating and restricting the introduction of new production techniques and methods in industry," " industrial education, training and promotion," and " effects of the introduction of automatic control principles on social attitudes and group relations in industry." The electronics industry has an intimate connexion with the programme in that part of the research into the implications of technological change is being carried out in several Scottish firms newly engaged on the development of electronic equipments. From the electronic engineering point of view, probably the most important researches are those into the effects of the introduction of automatic control, for this not only affects the productivity of our industry but, to an ever-increasing extent, its products, as a considerable proportion of modern automatic control is governed by electronic means. The effectiveness of the finest of automatic control equipment can easily be diminished, and even brought to nought, by an unco-operative attitude on the part of the workpeople. The method of introducing these techniques well deserves some study and it may amply repay those engaged in this branch of the art to follow the researches that are now in progress.

LEO

(Lyons Electronic Office)

By J. M. M. Pinkerton*, M.A., Ph.D., and E. J. Kaye*, B.Sc.(Eng.), A.C.G.I.

As announced in the April issue of ELECTRONIC ENGINEERING, *a large electronic digital calculating machine has been designed and built at Cadby Hall by J. Lyons & Company, Ltd., for use on their own clerical work. The first two parts of this article outline the history and principal features of the installation, which is believed to be the first of its kind in regular use, and discuss operating, maintenance and fault-finding procedures. The last part gives details of a foolproof checking device using relays for verifying the punching of telegraph tape used for input of data. The nucleus of the installation is a calculator developed from the EDSAC at the Cambridge University Mathematical Laboratory with the addition of a larger store and multiple high speed input and output channels. An extensive built-in system of marginal checking has greatly improved the serviceability of the equipment; occasional random intermittent faults occur in the 5 000 thermionic valves used, but they do not prevent a large output of accurate work. Data perforating errors are completely eliminated by the use of the checking device, provided it is properly maintained.*

THIS article is the first of three dealing with the history and design of LEO (Lyons Electronic Office) and the experience gained in operating it so far. A large number of automatic digital calculators using electronic circuit elements have now been described, but they were all designed to do scientific and technical calculations. In the offices of many large firms thousands of repetitions of simple arithmetical procedures following a prescribed routine are carried out every day. Lyons believed that this work could be done by an electronic calculator and LEO is believed to be the first installation put into service to have been specially designed for commercial clerical work of this kind.

The special features required of a machine intended for office work will first be discussed. There is no need for its speed to be any greater than that of the scientific machine, if by speed we understand the number of elementary calculations, e.g. additions or subtractions, performed per second. Indeed it has been found in programming clerical tasks experimentally for the scientific computors that only a few per cent of the inherent calculating speed of these machines could be utilized[1]. The reason is simply that the number of figures to be entered or recorded is great in relation to the number of individual arithmetical operations to be carried out on these figures, and the calculator is kept waiting both for fresh data to become available, and for the results to be discharged. Proposals have sometimes been made to accelerate the input process by recording at manual speed on magnetic tape or wire and reading at high speed into the machine, and the output by recording the answers at very high speed in the same way, and then reproducing results at leisure by medium or slow speed printers[2]. This may involve a delay of 15 to 30 minutes before the results can be inspected; experience to date suggests that this is undesirable in the office, where mistakes must be put right at the earliest possible moment. The problem has, however, been solved in LEO in another way by providing several independent medium speed channels for data and for results and by so designing the circuits of the various channels that each of the mechanical reading or recording devices can operate independently up to its maximum rate if required.

Again the necessity for producing results to time demands a very high standard of dependability, coupled with an efficient system of rapidly discovering and rectifying faults if they do occur. Measures taken to achieve these ends in LEO will be described in Part 2 of this article.

Clerical programmes tend to be longer than mathematical programmes, so the store in LEO has been made twice the size of that of a typical mathematical machine such as the EDSAC. This size permits a very large variety of jobs to be undertaken, although an even larger capacity would be useful for numerical information in certain cases.

For operating the calculator on routine work the simplest controls are all that are required, start, halt and restart being in effect the only manual controls needed. When trying out new jobs, or looking for faults it is very convenient to be able to advance a single order at a time or at slow speed. It is very desirable also to be able to inspect the contents of any selected portion of the store and the other registers. The control and monitoring facilities built into LEO are described in a later part of this article.

The execution of clerical work to time must depend on the availability of the data in a form the machine can assimilate, with a very low incidence of wrong figures. Because of the great volume of data this imposes very rigorous requirements on the recording process. Any individual wrong digit fed to the machine may cause a hold-up lasting half an hour or more; if the number of digits read may be as many as a million per week, some cheap and foolproof method of checking data is obviously essential. Part 3 in this series describes in detail a checking device that has been developed for verifying the perforation of telegraph tape, which is used as one vehicle for feeding data into LEO.

Historical Development

The story of LEO commences in the Autumn of 1947 when Mr. T. R. Thompson, a senior member of Lyons clerical department, visited the U.S.A. with a colleague to study war-time developments in office management and organization. While in the U.S.A. they inquired about the early electronic calculators such as ENIAC and the several other models in course of construction at that time and were convinced by what they heard of the feasibility of adapting an electronic calculator for clerical work. They also discovered that development was in progress at the Mathematical Laboratory at Cambridge, England, and soon after their return paid a visit to Dr. M. V. Wilkes and Professor D. R. Hartree at Cambridge. As a result

* *J. Lyons and Company Ltd.*

Fig. 1. General view of LEO

On the left the Hollerith card feed, card punch and printing unit with the power supply cubicles behind, in the centre the table carrying the two Ferranti Mark I photo-electric tape readers, on the right the racks carrying the electronic panels. The ultrasonic delay lines are in the low box on the extreme right. The dark strips in the flooring outline the runs of the underfloor ducting. Space has been allowed for duplication of the three items of Hollerith equipment.

of discussion with them it was envisaged that a modified version of the projected EDSAC which was then being built by Dr. Wilkes, might be used for clerical work. By June 1949 the EDSAC[3,4] was working and Lyons then decided to build a re-engineered copy of it themselves.

It was realized that this would be of limited value for clerical work as it stood, but it was hoped that it could be modified to become an efficient instrument for the purpose. It was thought that while this plan might not achieve the best possible design, no better one could be made before a calculator had been put to use on real clerical work. The nucleus of a technical group was engaged and engineering construction of the basic calculator started in September 1949 and was completed by the Spring of 1951; a very great deal of information and advice was freely given by Dr. Wilkes and his staff during this stage of the work.

Starting at the same time as the engineering work on the calculator itself, two other lines of development were initiated. First there was set up a section of experienced office systems planners to study the art of transferring office work to the calculator and writing the programmes for it. This group worked in the closest possible collaboration with the engineers and influenced their designs in countless ways. It would be out of place, however, to attempt here any description of their work, which embraces both the accumulated clerical experience of Lyons over several decades, and the newer art of organizing and programming calculations with automatic machines.

Secondly development of the input-output system was started. Means of keeping the machine fed with information fast enough to keep it busy and recording the results fast enough to prevent it being held-up by an accumulation of results, were visualized by Lyons. The simple fundamental ideas involved were capable of being implemented in various ways using any of the known media on which data can be recorded such as punched paper tape, magnetic tape or punched cards. The possibilities of magnetic tape were extensively explored in collaboration with a large electrical firm. After extensive work lasting more than three years, it was reluctantly decided that this particular system did not promise to give, within a reasonable length of time, the desired high standard of performance, and with it the vital operating experience, and so that equipment was dismantled.

In the meantime an alternative method of putting the original concept of the input-output scheme into practice was attempted. In this case standard mechanical units were chosen which had already proved their reliability in use over a period. Photo-electric tape readers were supplied by Ferranti Ltd[5], and a card reader, card punch and printing unit by the British Tabulating Machine Co., Ltd. The circuits for linking these mechanical units with the calculator and for using data and producing results, in forms adapted to each unit, were designed by Lyons.

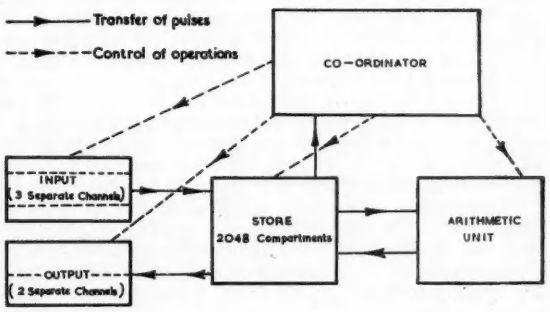
By the Autumn of 1953 the alternative system was clearly working well enough experimentally to warrant full scale operational trials on clerical work and it was decided to make it a permanent feature of the installation. This involved major alterations to the layout of the calculator room, including laying a new floor with concealed ducts carrying the numerous cables to the individual feeding and recording units. This work was completed on Christmas Eve 1953, by which date the evolution of LEO Mark 1 can be considered to have been substantially completed.

The following sections give general information about LEO; it will be apparent to many readers that some of the details are the same as for the EDSAC. However, since only a limited amount of information about the technical features of the EDSAC is readily available it is thought best to include these points here.

How LEO Operates

A highly simplified block schematic of LEO is shown in Fig. 2. The basic units comprise the store, which holds the instructions as well as the data for the problem, a number of input channels enabling instructions and data to be fed to the store, an arithmetic unit which carries out the calculations and operations required on the data in the store, and a number of output channels for recording the results. The automatic nature of the calculator demands that the instructions for any problem should be fed to the

Fig. 2. Diagram of basic units of LEO



store at the beginning and should then be carried out one after the other in the correct sequence. Control of the execution of the programme instructions is vested in the co-ordinator in the following way.

The control sequence is divided into two stages. During stage 1 the next order to be carried out is transferred from the store to a short register known as the Order Register. The compartment of the store from which this order is taken is specified by the number held in another short register called the Sequence Register. Stage 2 then commences, during which the order in the order register is decoded and carried out. When the order has been carried out, an end pulse is produced by the circuits concerned, e.g. the arithmetic circuits in the case of the "Add" order. This pulse causes unity to be added to the contents of the sequence register. It also initiates the next stage 1 so that the number in the sequence register having been

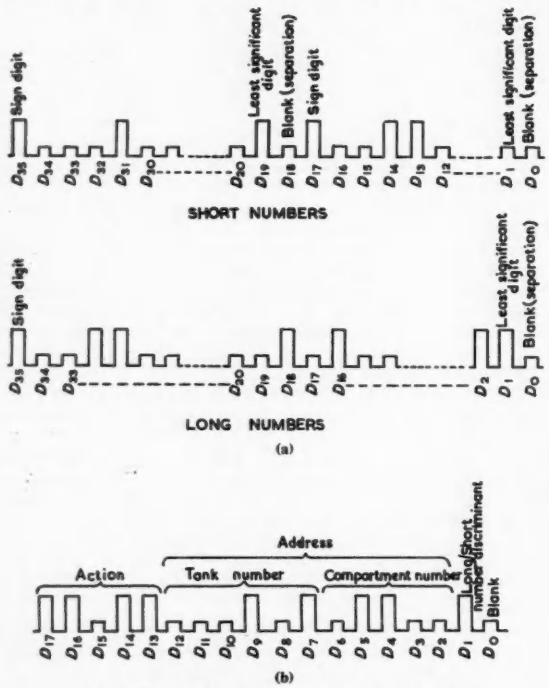


Fig. 3. Diagram showing form of numbers and orders

increased by "1", the next order is selected from the following compartment of the store.

In this way the orders are carried out one after the other. If no other method of operation were possible, however, the machine would soon stop, having carried out all the orders in the store. In fact, orders permitting a change of sequence are provided and these orders are conditional. That is, the contents of the accumulator are used to decide whether the sequence is to be changed or not. The conditions for changing sequence may be chosen to be that the accumulator contents are positive, negative, zero or not-zero. If the condition is satisfied the contents of the order register are transferred into the sequence register, and consequently the next order to be carried out will be selected from the compartment of the store given by the address digits of the sequence changing order.

Numbers and instructions are held in the calculator in binary code. The construction of short and long numbers is shown in Fig. 3(a). The short number occupies a single compartment of the store and consists of 17 binary digits, the most significant of which is the sign digit. Long numbers occupy two adjacent compartments and comprise 35 binary digits. The digits are represented by pulses of 1μsec duration and repetition rate of 514kc/s. The pulse positions are numbers D_0 to D_{35}. The D_0 position is always blank in order to provide time for switching. In the case of short numbers, both D_{18} and D_0 positions are left blank.

A typical instruction is shown in Fig. 3(b). Like the short number it consists of 17 binary digits. There are two main classes of instruction, those which require access to the store during stage 2 and those which do not. The five most significant digits of the instruction represent the action required. Where access to the store is required the next eleven digits specify the address of the storage location. The least significant digit indicates whether the

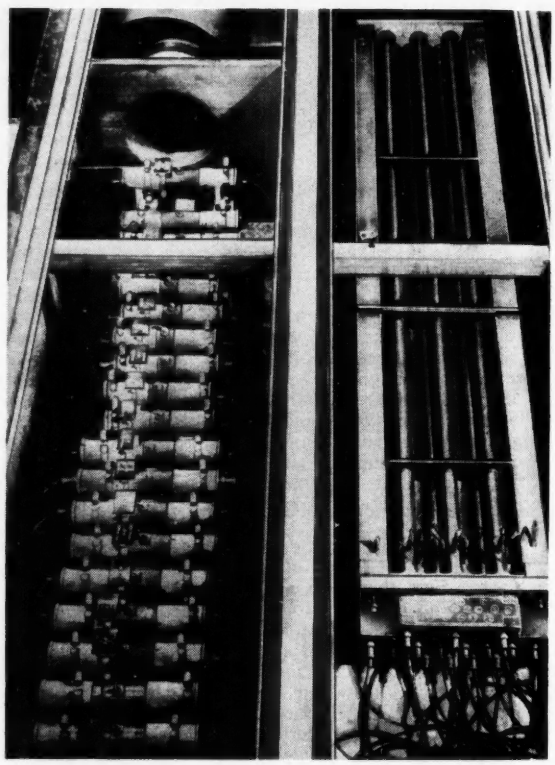


Fig. 4. Photograph of part of the interior of delay line vault with lids removed

On the right is a battery of 16 long delay lines showing the filler tubes and coaxial cables plugged into one of the matching unit assemblies; on the left are all the short delay lines each holding one short or long number. At the back is the fan used for circulating air round the interior of the box.

operand of the order is to occupy a single or double compartment of the store. For orders not requiring access to store the address digits can be used for other purposes appropriate to the particular order (e.g., for multiple left and right shifts one digit is used to indicate how many positions the number in the accumulator is to be shifted).

Engineering Features of Design

The Store

The store in LEO is closely similar to that of the EDSAC[3], but is of twice the size; it will therefore hold up to 2 048 orders or short numbers. It uses 64 mercury delay lines each having a capacity of 32 short numbers or orders assembled in five batteries of 16 lines each. There

are thus a number of spare lines. The batteries are housed in a thermally insulated vault (Fig. 4), through which the air is kept circulating. One line is used in conjunction with an automatic frequency control circuit[6] to control the frequency of the system to 9 parts in 10^5. Since installing this system it has not been found necessary to employ temperature control, although the vault has been fitted with heaters and a thermostat which can be used if required.

A carrier frequency of 13·5Mc/s is amplitude modulated by 1μsec pulse trains in an electronic unit associated with each line. The signals are fed through a coaxial cable from the storage unit and applied via a matching unit to the X-cut transmitting crystal; an ultrasonic pulse travels through 64 inches of mercury to an identical receiving crystal. The total delay is 1·12msec.

Electrical pulses from the receiving crystal are fed, via another matching unit and coaxial cable back to the storage unit. Here they are amplified, detected, reshaped, gated with master clock pulses and sent back to the transmitting end of the line. This arrangement has been described by Wilkes and Renwick[3].

Pulses may be gated in and out of the circulation by input, output and clear gates. The input and output gating waveforms are timed by a coincidence circuit in the co-ordinator, and directed to the input or output gate of one of the 64 storage units by a decoding network, controlled by the address digits of the instruction. These digits are set up on the so-called static register and control the path taken by the coincidence waveform through the decoder. Decoding is carried out in three stages (Fig. 5); the first determines which half of the store is required, the second which group of eight units in that half of the store and whether input or output and the third to which unit of that group of eight the coincidence waveform should be routed. In stage 1 output from the store is always involved, in stage 2 the choice of input or output is governed by the instruction itself. "Add" and "Subtract" for example call for output, whereas "Transfer" (to store) obviously calls for input.

Where input is called for, the inverse of the routed coincidence waveform to a particular storage unit is generated in the final decoder and applied to the clear gate of this storage unit, thus ensuring that the old contents are always cleared when new information is being fed in.

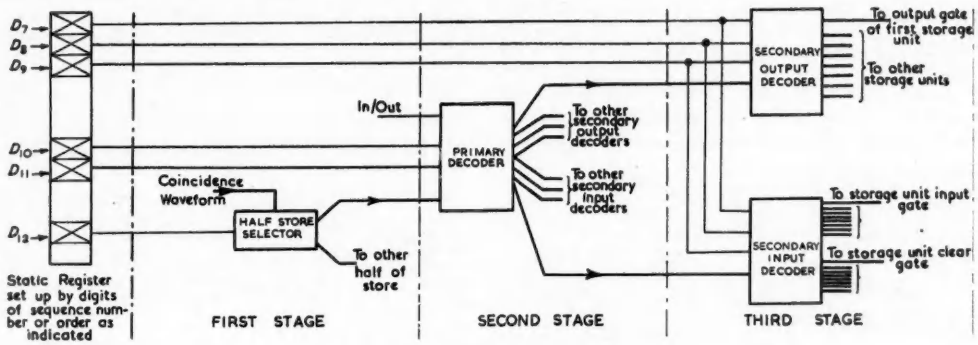


Fig. 5. Simplified diagram of decoding system

The heavy lines show the route taken by the coincidence waveform.

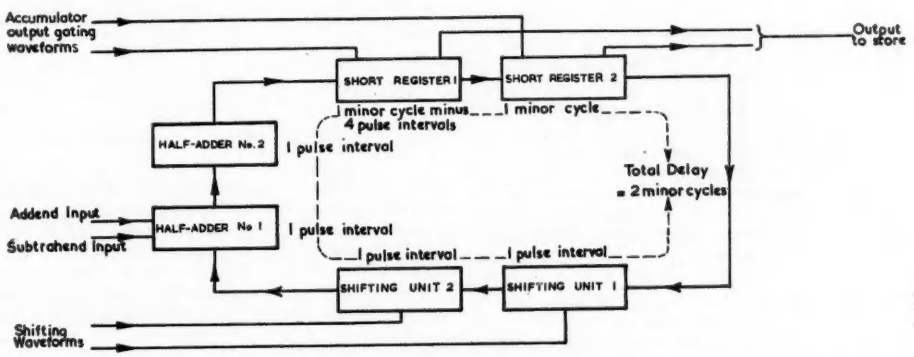


Fig. 6. The accumulator loop

In the filling of the delay batteries a novel wetting agent for making contact between the crystals and mercury has been successfully used in place of alcohol which was found to evaporate. This is a mixture of five parts of glycerine and two parts of water, and has resulted in a very stable and consistent performance from all the delay lines over a considerable period.

Arithmetic Unit

The arithmetic unit consists of an accumulator, in which addition and shifting are carried out, a complementor, used for subtraction, and multiplicand and multiplier registers used not only in multiplication but also as special purpose registers for other instructions. The arithmetic processes used resemble in certain respects those of the familiar 3-register type of desk calculating machine. The fact that the binary system is used has the effect of making certain simplifications[7].

The accumulator (Fig. 6) is a loop two minor cycles in length, thus accommodating the complete results of a multiplication of two long numbers. It includes two "half adders," two short registers and two shifting units. A half-adder[8] is a combination of logical circuit elements adapted to add together binary digits from not more than two sources. Thus it will add "1" to any binary number but will not in general form the complete sum of two binary numbers bigger than one, since it cannot deal simultaneously with the "carry" digits. Two half-adders can, however, be readily combined to do the complete operation of adding two numbers. It is convenient to use two half adders rather than a whole adder as half adders can be used in conjunction with two other short registers in the calculator, where only unity has to be added to a binary number. Numbers always enter the accumulator loop via the two half-adders and are therefore automatically added to the previous contents. In subtraction, the subtrahend is routed through the complementor, and the resulting complement of the number is added into the accumulator. A number may be extracted during any minor cycle by opening the gate in the appropriate short register.

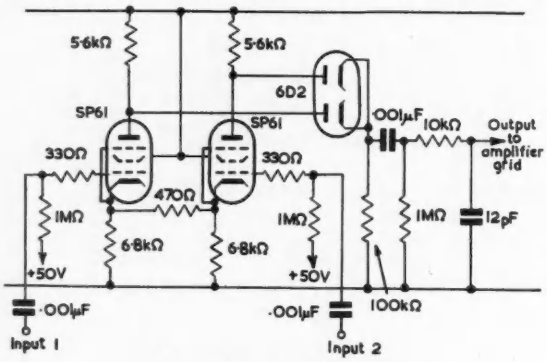


Fig. 7. Coincidence seeking circuit

The number in the accumulator may be shifted by one position to left or right by lengthening or shortening the loop by one pulse interval. Shifting waveforms lasting two minor cycles applied to the accumulator shifting units, cause the pulses either to pass through an additional delay of one pulse interval or to by-pass a delay of one pulse interval normally in circuit. For a shift of more than one place the shifting waveform lasts for $2n$ minor cycles, where n is the number of shifts.

In binary arithmetic, multiplication is essentially a series of additions and shifts. A separate order is required to transfer the multiplier to the multiplier register and multiplication is then carried out by inspecting the digits in the multiplier register one at a time and adding the contents of the multiplicand register to the accumulator whenever a "1" is present in the multiplier. The contents of the multiplicand register are shifted after each step of the process in a special unit, i.e., the multiplicand shifting unit.

The timed waveforms and control pulses required to operate the units described above are produced by 13 subsidiary control units, which unfortunately are too elaborate to describe in detail.

Circuits are provided for testing the contents of the accumulator to see if they are positive, negative or exactly zero, and emitting a sequence changing pulse in place of an end pulse if a sequence changing order of the appropriate type so demands.

The Co-ordinator

The logical arrangement of the co-ordinator closely resembles that of the EDSAC[9]; in LEO it consists of four control units and two coincidence units.

The coincidence units emit the timed waveform for selecting the required compartment or double compartment from the store. The correct timing of this waveform is obtained by comparing digits D_2 to D_6 inclusive of the sequence or order patterns with the corresponding digits from a "counter register" into which "1" is added regularly every half minor cycle. The pulse patterns in the positions D_2 to D_6 in this register therefore represent in turn the binary numbers 0 to 31, and may be thought of as enumerating the compartments as they circulate in the various long storage lines. The two pulse trains are applied simultaneously to the inputs of a coincidence seeking circuit, a balanced circuit with two inputs and one output (Fig. 7). If the inputs are identical, no output is produced and "coincidence" is established, i.e., the coincidence waveform is emitted by a special flip-flop. If they differ, one or more pulses are produced at the output which are used to prevent the setting of the coincidence waveform flip-flop. In stage 1 the sequence and counter register patterns are compared, and the coincidence waveform selects the compartment of the store from which the next order is to be taken. In stage 2, for those orders which require access to the store, coincidence is established between the counter register and the order register. During stage 2 the orders are decoded and recoded to form waveforms which operate gates in the arithmetic and input and output units. This arrangement resembles that of the EDSAC[9].

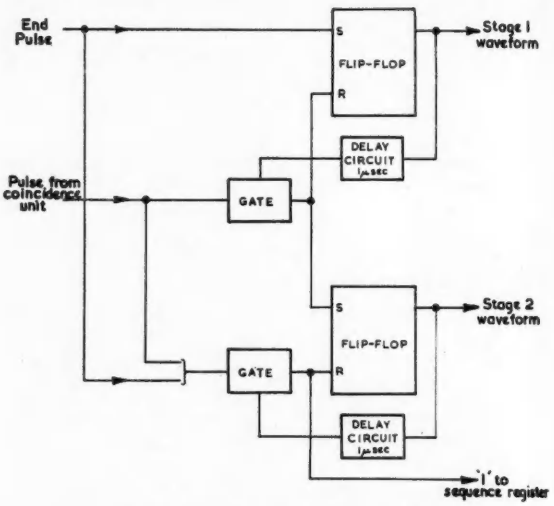


Fig. 8. Stage 1-2 control circuit simplified

The principal control unit of the co-ordinator contains two flip-flops emitting the stage 1 and stage 2 waveforms. (A simplified block schematic is shown in Fig. 8.) The stage 1 flip-flop is set by the end pulse of the previous order. Its output is used to open a gate which permits the contents of the sequence register to be applied to the coincidence circuit. A pulse following the completion of the coincidence waveform resets the stage 1 flip-flop and sets the stage 2 flip-flop, whose output is used to open a gate to route the contents of the order register to the coincidence circuit. This flip-flop is reset either by a pulse from the coincidence unit following the completion of the coincidence waveform (in the case where access to the store is required by the order) or by the end pulse of the order.

Another co-ordinator control unit controls the addition of "1" to the sequence register, and emits the waveform

which permits the transfer of the contents of the order register to sequence register in the case of a sequence changing order. A further unit is concerned with releasing the sequence number or order to the static registers at the commencement of stage 1 and stage 2 respectively.

Input and Output

Originally the input and output equipment of LEO was very similar to that of the EDSAC, namely, a low speed mechanical reader for input from punched paper tapes at 10 rows of holes per second, and a teleprinter, modified for parallel five-wire operation and printing 7 characters per second. This equipment is now obsolescent. The present system provides three independent high speed input channels from two Ferranti photo-electric tape readers and a Hollerith card feed, and two independent high speed output channels operating a Hollerith card punch and printing mechanism of a Hollerith tabulator. It is a special feature of the circuit design that all these devices can operate simultaneously with one another and with calculation if necessary.

Data can be read from the punched tapes at 130 rows of holes per second, a row of holes representing one decimal digit. Combinations are reserved to indicate the

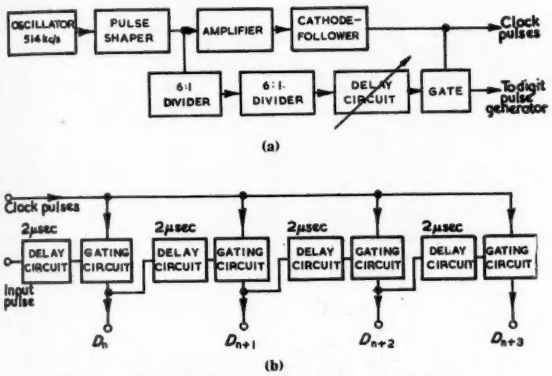


Fig. 9. Clock pulse generator and digit pulse generator

end of a number, the end of a block of numbers and minus sign. Blank tape and "all holes" are ignored by the input circuits; characters may thus be "erased" by overpunching with the "all holes" combination during punching or checking.

Punched cards are used for reading in the programme of instructions and data brought forward. The card feed reads at the rate of 200 cards per minute, each carrying up to twelve binary numbers of 35 digits. Although numbers are usually punched on cards in the binary form they may also be punched in the Hollerith positional code if desired.

The Hollerith printing mechanism has 80 print bars arranged in two fields of 40 and is fitted with slugs corresponding to the figures from 0 to 11. Signals from the calculator are set up on 35 relays which in turn set up any selected 35 print bars during one tabulator cycle. On receipt of a signal from the calculator all 35 lines can be switched by relays to an alternative selection of print bars, so that printing can take place, for example, either on the left-hand or right-hand side of the paper. Thus if no line feed signal is sent between the changeover, up to 70 columns can be printed on each line. Printing takes place at the rate of up to 100 lines per minute.

The card punch operates in a similar manner to the tabulator, the signals from the calculator being set up on another set of 35 relays which operate the punch magnets. These relays are grouped together with the tabulator relays in a dust-tight box and are mounted on small plug-in panels for ease of replacement and maintenance. Cards can be punched at the rate of 100 cards per minute.

Pulse Generator

All pulses are formed from a single source of master clock pulses in the clock pulse generator unit (Fig. 9(a)). The sine wave output of a 514kc/s Franklin oscillator is applied to a two stage squaring circuit to form the clock pulses. As explained previously the frequency is automatically controlled and the phase relation between the delayed and undelayed pulses in the store is displayed on a special frequency monitor oscilloscope mounted on the monitoring control desk. A single triangulated pulse is shown, the apex of the triangle being brightened symmetrically when phasing is correct. Any drift in either direction causes an asymmetry in the pattern.

The input pulse to the digit pulse generators is formed by a 36-way divider, composed of two 6-way phantastron dividers in series, which employ a cathode-follower in the anode-grid feedback loop to diminish recovery time, thus giving increased stability. In order to overcome the time delay in the divider circuits, the output of the second

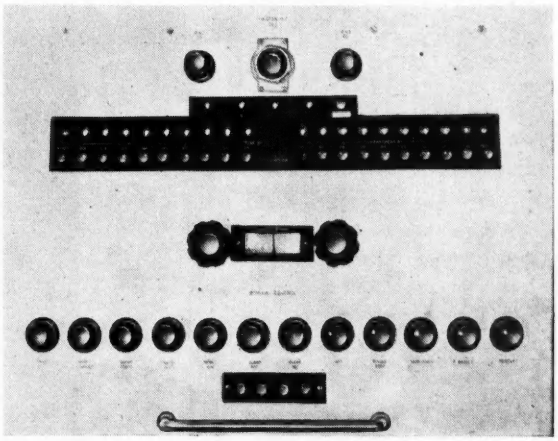


Fig. 10. Close-up of operating controls

At the top are the buttons for inserting pulse patterns by hand, in the centre the two selector switches for choosing the storage line to be inspected on an oscilloscope, and at the bottom the push buttons mentioned in the text.

divider is applied to an adjustable delay circuit before gating out one of the clock pulses. This pulse is applied to the first of a series of digit pulse generators. The block schematic of one of these is shown in Fig. 9(b). Each pulse in turn is delayed by 2μsec (one pulse interval) and gates out the next clock pulse.

The clock pulses which are used extensively as timing pulses throughout the whole machine, and certain digit pulses which are widely used as control pulses, are distributed to other units of the calculator from a distributing unit consisting of a number of cathode-followers.

Operating Controls and Monitoring

By means of push-buttons mounted on a central control panel (Fig. 10) it is possible to START and HALT the calculator. The START button causes a fixed programme of initial or starting instructions to be read in from a selector switch[10]. These orders then allow the programme tape to be read. Additional START buttons are provided for use when taking in programmes via the Hollerith card feed or Ferranti tape reader. In these cases special starting instructions are located on the first few cards or at the beginning of the tape. After being halted the calculator may be made to continue one order at a time by

means of a button marked SINGLE STEP or at one of three intermediate speeds by three SLOW SPEED buttons. Normal operation can be resumed by pressing a RESTART button. The store, sequence register and accumulator can be cleared by three further buttons. Pressing the REPETITION button causes the calculator to repeat one order indefinitely and pressing REPETITION STEP causes it to repeat the order in the next storage location. These are chiefly useful for fault finding. By means of a further row of buttons a number or order may be inserted manually into any compartment of the store.

The contents of the store may be monitored on an oscilloscope which displays on a raster the contents of one of the long lines of the store[11]. A multi-way switch enables the contents of any of the 64 storage lines to be inspected. The contents of the accumulator, the counter and the slow speed input channel are depicted on separate cathode-ray tubes. The contents of the multiplicand and multiplier registers are displayed on one double-beam tube, and of the sequence and order registers on another.

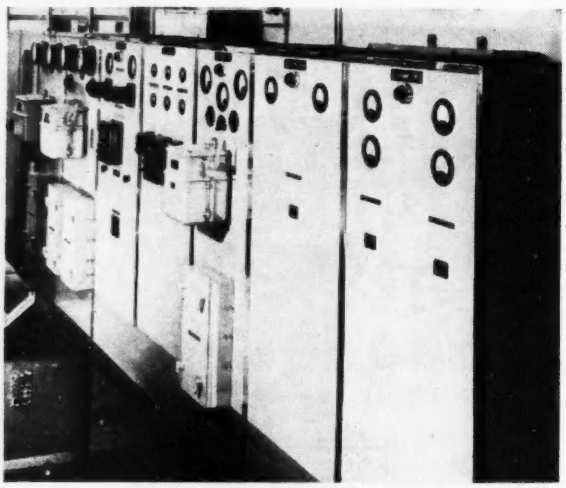


Fig. 11. General view of the power supply cubicles

The various rectifier sets are mounted in separate cubicles; the voltage controlled motor alternator set is in another room in the basement. All incoming feeders are filtered to remove mainsborne interference, and room services are kept separate from calculator power wiring.

POWER SUPPLY

The total power consumption of LEO is of the order of 30kW. The heaters are supplied from an 18kVA regulating transformer which can raise and lower the voltage slowly over a period of two minutes, either automatically or under manual control.

Three-phase rectifier sets provide +250V D.C., and −200V D.C., supplies (Fig. 11). There are two +250V supplies, the first a 30A supply for general H.T. requirements and the second a 2½A supply for special purposes (H.T. for flip-flops and amplifiers) where better smoothing is called for. Similarly there are two −200V supplies, one of 7A and the other 1·5A. Auxiliary −50V D.C. and +110V D.C. rectifier sets feed relay circuits and punched card equipment respectively.

The power for the H.T. rectifiers is derived from a 12kW alternator driven by a 20 h.p. induction motor. Two generators, with changeover facilities permit servicing and provide standby facilities.

An electronically controlled automatic voltage regulator, controlled from one of the outputs of the rectifier set, maintains the output voltage stable to within ±½ per cent.

MECHANICAL FEATURES

The electronic part of LEO consists of 228 easily replaceable units mounted in fixed racks. The units slide into the rack between guides, and power is connected from a terminal block on the rack to an 8-pin plug on the side of the unit. The racks can hold up to twelve units and carry power wiring and inter-unit pulse wiring. This pulse wiring terminates on tag strips fixed to the rack framework. Pulse connexions between the tag strip and the unit are made by flying leads, carrying spade terminals which can be connected to the screw terminals on the tag strip. The pulse leads can be seen in Fig. 12 supported on a gantry on the valve side of the chassis. Thus any unit can be replaced in a few minutes by a spare. The layout has been arranged so that the components are

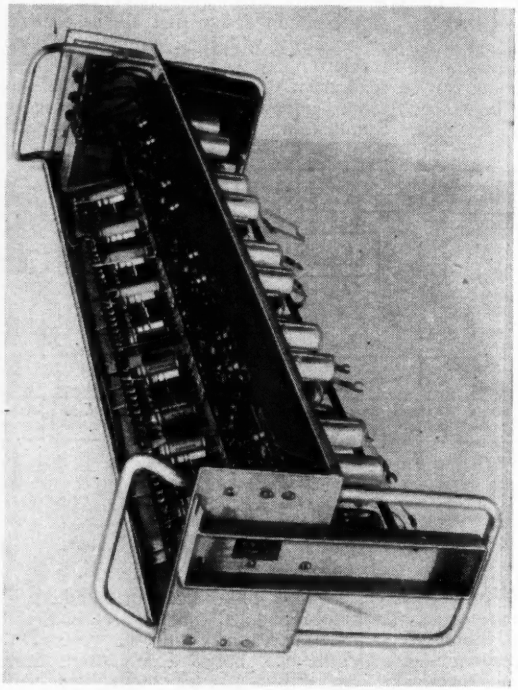


Fig. 12. A typical unit showing component mounting, valves, heater transformer, pulse leads ending in spade tags and power supply plug

Long runners at either end guide the unit into the rack and carry its weight when in position.

readily accessible. The chassis can accommodate up to 28 valves, but generally only 20-25 valve positions are used. Current monitoring points are provided on a central gantry. Each chassis carries H.T. and L.T. fuses and one or two heater transformers for up to 15A.

The racks are nine feet high and are fitted at the top and bottom with ventilation ducting. Each is fitted with a set of removable covers so that the units are totally enclosed. The intake fan on the ventilation system forces cool filtered air past the valves through a grille in the lower duct, and the warm air is extracted through the top duct by an extract fan. A false floor has been constructed around the four rows of racks to a height of 1ft 6in above ground level so as to cover the lower ventilation ducts and conduit runs and bring the top unit in the rack within reach.

The calculator is connected to the input-output equipment by many multi-way cables which run in shallow concealed ducts under the floor.

Preliminary Conclusions

The installation of LEO Mark I has now been in use for long enough to allow tentative conclusions as to its utility to be drawn, and give an indication of the improvements desirable in future models. Conclusions based on our operating experience will be given at the end of Part 2. Here we shall deal with the engineering aspects of our experience.

The general physical construction of the machine should be such as to keep it and the operators as cool as possible, and give easy access to all parts. It should be possible to dismantle it into easily portable sections and re-erect it again on another site without extensive building alterations, e.g., to bury wires under the floor or install air ducts for ventilation. It will be evident that LEO Mark I does not fully satisfy this requirement.

To simplify maintenance all parts should be easily replaceable on a plug-in system. The tag connexions used in LEO Mark I have some disadvantages; it takes rather too long to change a unit and faults have sometimes occurred through tags working loose or being left undone. Spares should certainly be provided for all repeated units such as storage units, but if they are to be provided for others it is vital that they should be completely mechanically and electrically interchangeable; otherwise they are worse than useless.

In order to maintain the installation in service with the least possible interruption complete duplication of all mechanical devices such as tape and card readers, punches, printers and generators is considered essential. When failures occur in equipment of this type there is often considerable delay before a spare part can be obtained, or the mechanism dismantled to fit it and reassembled and tested. A rapid changeover to the standby should therefore be possible, by the use of switches or plugs and sockets.

The tolerances and power rating of all components should be carefully specified. Ideally the circuit would be tested with the most unfavourable combinations of limiting values. A suitable factor should be allowed for the inevitable falling off in valve emission, and both valves and resistors should be used at a fraction of their maker's ratings. We have in fact derated resistors to 50 per cent and valve dissipations to 80 per cent of the normal figures. We have also tried to ensure that valves had available twice the necessary current emission before the onset of grid current, to ensure that a valve with only 50 per cent of the new emission would still function in the circuit.

Perhaps the most important conclusion is that the simpler the conception and the design of any item of calculating equipment, the better it will be understood by the operators who use it and the engineers who maintain it. A calculating system can be and should be made from a relatively small number of simple circuit elements whose design should be carefully studied and then fixed. If adjustable controls have to be provided they should be as tolerant of wrong adjustment as possible, and set up in accordance with a prescribed set of instructions.

Acknowledgments

It is obvious that a project of this size could not have been carried through without the enthusiastic co-operation of many individuals, and the authors wish to acknowledge the help given to the project by all their colleagues and those in the many other companies and organizations who took part. In particular they wish to record their indebtedness to Mr. T. R. Thompson for his wise direction and unfailing encouragement during the whole course of this work. Thanks are also due to J. Lyons & Company Ltd., for permission to publish these articles.

(To be continued)

REFERENCES

1. Shaw, R. F. Payroll Accounting with Elecom 120 Computer. Proc. West. Comp. Conference, p. 54 (Inst. Radio Engrs., 1953).
2. Gray, W. H. Report on the Joint A.I.E.E.-I.R.E. Computer Conference, December, 1952, p. 70 (Inst. Radio Engrs., 1953).
3. Wilkes, M. V., Renwick, W. An Ultrasonic Memory Unit for the EDSAC. *Electronic Engng. 20*, 208 (1948).
4. Wilkes, M. V. The Design of a High-Speed Computing Machine. *Proc. Roy. Soc. A, 195*, 274 (1948).
5. Byrd, D. J. P., Welby, B. G. Report of Joint A.I.E.E.-I.R.E. Computer Conference, December, 1952, p. 123 (Inst. Radio Engrs., 1953).
6. Pinkerton, J. M. M. Automatic Frequency Control. *Electronic Engng. 23*, 142 (1951).
7. Shaw, R. F. Arithmetic Operations in a Binary Computer. *Rev. Sci. Instrum. 21*, 687 (1950).
8. Stifler, W. W. (Editor). High-Speed Computing Devices, p. 269 (McGraw-Hill, 1950).
9. Wilkes, M. V., Renwick, W. J., *Scl. Instrum. 26*, 385 (1943).
10. Wilkes, M. V., Wheeler, D. J., Gill, S. The Preparation of Programmes for an Electronic Digital Computer, p. 15 (Addison-Wesley, 1951).
11. Lenaerts, E. H. Visual Presentation of Binary Numbers. *Electronic Engng.* 140 (1951).

A New Impedance Matching Arrangement *

The problem of coupling two lines or networks of differing impedances so that reflexions at the coupling are avoided is a common one in the electronic art and usually presents no difficulties. An aspect of the problem that is not frequently met and is not so easily solved is that in which there is to be no change of signal level across the coupling and where signal transfer is to occur in both directions. Clearly it is not possible to use purely passive couplings since these will result in a change in the intensity of the signal; and in general with valve couplings the signal is only transmitted in one direction.

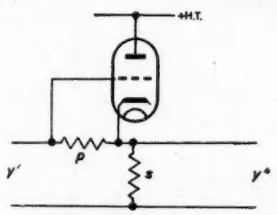


Fig. 1. The circuit described

It has been found that the problem may be solved by a form of cathode-follower circuit provided that the circuit parameters are appropriately chosen. The connexions of the arrangement are shown in Fig. 1. With this arrangement if y' and y'' represent the respective characteristic impedances of the lines or circuits to be coupled, as indicated in the diagram, y'' being larger than y', and if p and s are the conductances of the resistors connected between grid and cathode and between cathode and ground, it may be shown that the conditions for no reflexion are:

$$y'y'' = ps$$

and

$$p = \frac{\alpha g}{2(1-\alpha)} + \sqrt{\left(\frac{\alpha^2 g^2}{4(1-\alpha)^2} + \frac{y'^2}{1-\alpha}\right)}$$

where

$$\alpha = y'/y''$$

and where g is the mutual conductance of the valve. In these circumstances and if g is large compared with y'' then the change in signal intensity in transfer through the circuit is small for both directions of transmission and the arrangement provides a satisfactory practical solution of the problem.

If the value of g/y'' is sufficiently high the required value of s approaches zero and the resistor connected between cathode and ground may accordingly be omitted. It may also be shown that if g is not too small the resistor connected between cathode and ground may be transferred so as to lie in shunt with the admittance y', suitable adjustments being made in the values of p and s.

* *A communication from E.M.I. Ltd.*

Recording Television and Sound Signals on Magnetic Tape*

A system for recording and reproducing television signals by means of magnetic tape is discribed. This system is applicable to both colour and monochrome pictures. For monochrome pictures two tracks on a ½in tape are used while for colour, five tracks on a ½in tape are used. The tape speed of 30ft/sec is maintained constant by an electronic servomechanism. The recorded and reproduced frequency band is over 3Mc/s.

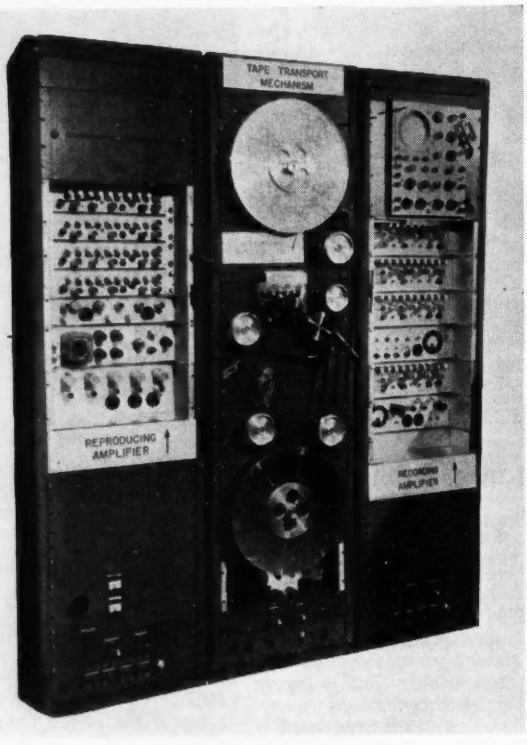
THE system to be described will record and reproduce both monochrome and colour television pictures, and was demonstrated at the RCA Laboratories at Princeton, New Jersey, in December 1953.

Tape

The tape used in this development consists of a cellulose acetate base coated with a red iron oxide. The acetate base has a thickness of ·0017in and has an iron oxide coating of about ·0004in thickness. The width of the tape used for colour television reproduction is ½in—equivalent to 12·7mm; for monochrome only ¼in width tape is required, so that two parallel programmes may be recorded on a ½in tape. The coercive force of the tape used in the demonstration was 250 oersteds, with residual magnetization of 770 gauss.

Tape Transport Mechanism

The tape transport mechanism has been designed to keep any sudden speed changes to a minimum in order to eliminate jitter in the pictures. The order of constancy required can be appreciated when it is realized that a sudden speed change of one part in a million will put a jog of about 5mm (1/5in) in the picture on a 30cm (12in) kinescope. Furthermore, any slow drifts in speed have to be limited to considerably less than one picture element per scanning line.



The recording and reproducing equipment.

A schematic diagram of the tape transport system is shown in Fig. 1. The basic speed of the tape feed is determined by a capstan driven at approximately 30 revolutions per second, and having a circumference of 30cm or 1ft. Sudden changes in capstan speed are filtered out by a flywheel. The bearings on this flywheel assembly require to be very smooth and perfectly aligned, and both static and dynamic balance of all parts must be made with high precision. Even with accurate tape speed established by the capstan, tension in the tape supply and take-up must be held very exact or momentary changes in tape position will be introduced by stretch in the tape. Constant tension on the supply reel is maintained by driving a generator from the supply reel shaft and using feedback to control the generator load to a constant tension load. The control must hold over a speed range of from 30rev/min with a full reel to over 600rev/min when the reel is empty. The take-up reel is motor driven and has its feedback circuit arranged so that a constant tension on pull-out is obtained. Both supply and take-up tensions are held constant whether the reels are empty or full. In the diagram it will be seen that there are four fixed idler pulleys to guide the tape from the supply reel over the heads and capstan, and one to the take-up reel. A rubber surfaced idler is sprung against the capstan to act as a depressor in holding the tape on the capstan for speed determination.

The tape reels are an important part of the transport mechanism; they must not have excessive inertia if a practical starting time is to be achieved, and must be accurately balanced to enable full advantage to be taken of the constant tension drives. The playing time of a full reel is dependent on the diameter of the reel, the thickness of the tape, and its running speed. The present reels are 17in in diameter, and have a hub of 8in diameter. With a tape thickness of ·0021in a full reel contains approximately 7 000ft of tape. This length of ½in tape weighs approximately 4·3lb and will play for about four minutes at 30ft/sec, equivalent to about 20 miles per hour. A 15 minute period is normally considered desirable for television programming, and an objective of current research is to achieve this playing time with reels 19in in diameter.

* *This article is based on a lecture given by C. G. Mayer, RCA European Technical Representative, at the Conference on Sound Recording, Paris, 1954. The engineers responsible for this development were Dr. H. F. Olson, W. D. Houghton, A. R. Morgan, J. Zenel, M. Artyt, J. G. Woodward and J. T. Fischer, all of RCA Laboratories Division, Princeton, U.S.A.*

Recording and Reproducing Heads

The enormity of the problem of recording video signals on magnetic tape will be apparent to anyone acquainted with sound recording on tape. Simple calculation shows that a frequency of 4Mc/s recorded on a tape travelling at 30ft per second, results in a wavelength on the tape of less than 1/10 000in. Obviously the effective gap length of the heads must be considerably less than the wavelength to be recorded, and there is a very real problem in producing heads having the exceedingly small gap dimensions needed for this purpose. Moreover, head gaps must be very carefully aligned in order to permit tapes to be recorded on one set of heads and reproduced on another without loss of overall performance.

When one considers that some 16 to 18 octaves of frequency range must be covered, it will be realized that to obtain the desired electrical and magnetic characteristics of the heads is indeed a formidable problem. The magnetic material must be such that a high permeability is maintained over the whole frequency range; likewise the electrical impedance of the coil which surrounds the magnetic path of the head must remain reasonably constant, and be entirely free from resonances, especially in the higher frequency range. The physical configuration of the heads must also satisfy a number of conditions. Firstly, the assembled head must be stable with time against variations due to temperature and humidity. Secondly, the head must have good wear resistance to the abrasive effect of the passage of tape. Thirdly, the head must be physically small to allow of grouping for multiple channel working such as is used in recording and reproducing of colour pictures. There are also several other mechanical requirements to be met involving the mounting of the heads, shielding of the electrical connexions, head position adjustments and so on. Notwithstanding these difficulties, it has been possible to develop a set of heads that appear to give a reasonable solution to all the problems.

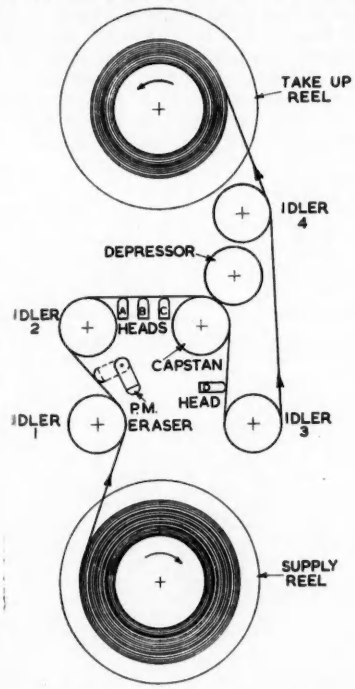


Fig. 1. Arrangement of the tape transport mechanism

Fig. 2 is a photograph showing the present arrangement of the head assembly for recording colour video signals on tape. The left-hand head is for recording sound. The central head is for video recording and is made up of four elemental heads to provide four channels. The right-hand head is for video reproducing and also contains four elemental heads. For the sake of expediency, the sound reproducing head is placed at a point following the tape drive capstan. In a final design both video and sound heads would probably be incorporated in a single unit.

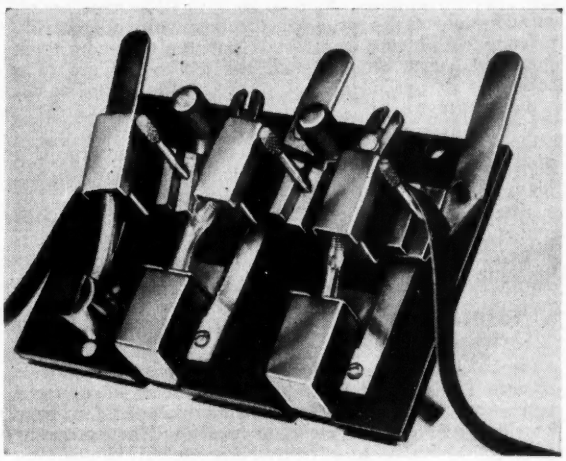


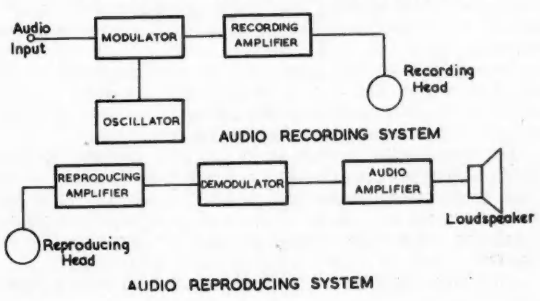
Fig. 2. The sound and video recording and reproducing heads

Tests have established that the frequency response of the heads is uniform with a reasonable signal-to-noise ratio up to approximately 3·5Mc/s, and that the impedance of the elemental head is free of resonances to the highest frequency. The wear properties of the heads, although not completely studied, have proved satisfactory.

Audio Recording and Reproducing System

In conventional magnetic tape recording systems used for audio frequency work, the tape usually moves past the heads at a speed in the neighbourhood of 15in per second. With such systems careful design and adjustments are necessary to enable frequencies, say above 10 000c/s, to be handled satisfactorily, because of the extremely short wavelength of these higher audio frequencies. In video recording where tape speed is nearly 25 times as great, the situation with respect to recording audio frequencies is reversed. It is now more difficult to record and reproduce the lower audio frequencies at useful levels above noise, because of the extremely long wavelengths of the lower frequencies. For example, a 100c/s tone recorded by the video tape system has a wavelength of nearly 4in, while the same tone recorded on a conventional audio tape

Fig. 3. The audio recording and reproducing system



recorder has a wavelength of only 1/10in or less. A consideration of this problem, together with the necessity for complete absence of crosstalk between the audio track and the adjacent video tracks, has led to the use of a modulated carrier method of recording the audio signals in the present system.

A block diagram of the audio system is shown in Fig. 3. It will be seen that the signal recorded on the tape is a carrier which is amplitude modulated by the audio signal, and which requires demodulation for reproduction. The recording and reproducing amplifiers both employ tuned circuits, and have a pass-band centred at the carrier frequency, which is 150kc/s. The audio heads are essentially similar to those used for the video channels.

Video Recording and Reproducing System for Colour Television Signals

The block diagram of Fig. 4 shows the basic components required for recording a composite colour video signal such as may be obtained from a microwave link or from the video output of a television receiver. The composite video signal is fed to a colour demodulator which produces, as separate outputs, the three colour video signals (red, green and blue) and also the associated synchronizing information. The four signals thus obtained pass through recording amplifier units to their respective recording heads. The sound or audio signal modulates a carrier as previously described, and passes through a fifth recording amplifier to the audio recording head.

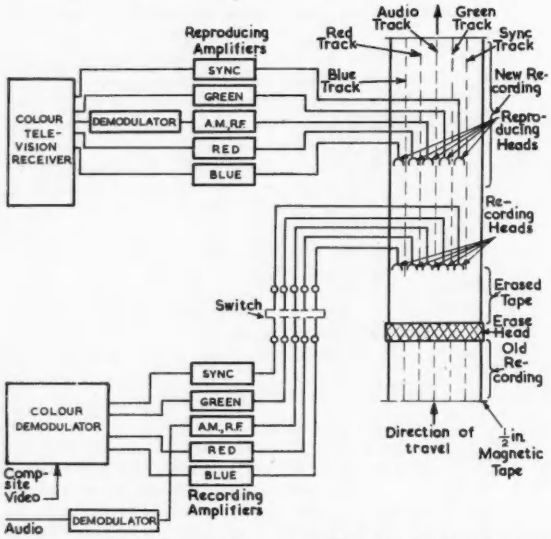


Fig. 4. Recording and reproducing colour video signals and audio signals

The recording amplifier units are designed to provide both phase and frequency compensation in order to obtain the desired flux patterns for recording, and in this way the signals are recorded on five separate tracks on the magnetic tape.

As indicated in the diagram, the tape travels in an upward direction, and it will be seen that an erase head is provided to remove all previous information from the tape, and to condition the tape for recording.

The erase head consists of a specially designed permanent magnet which subjects the individual elements of the tape to reversing magnetic fields and leaves the tape in a fixed magnetic condition. This head is physically removed from the tape path when the erasing operation is not desired.

The tape then travels past the recording heads where new information is stored on the tape in the form of a flux pattern corresponding to the signal. The energized tape next passes the five reproducing heads in which electrical signals are generated corresponding to the flux patterns stored on the tape. These signals can be used for reproducing or monitoring purposes. Since the reproducing heads do not change the flux pattern, any desired number of reproductions may be obtained merely by running the tape through the machine with the erase head removed and the recording heads de-energized.

Each of the recording amplifiers contains a special biasing unit which supplies an appropriate signal to the tape so that the full magnetic amplitude range may be used for the video signal. That is, the "black" level of the video wave is made to occupy a particular value on the magnetic characteristic of the tape. The "white" signal components then vary the magnetic change relative to this value. The signals derived from the magnetic tape are essentially in the form of the output signals from a television colour camera. In order to use these signals to modulate a television transmitter, it is necessary to combine them to form the proper composite signal for transmission, just as is done with camera signals at a studio.

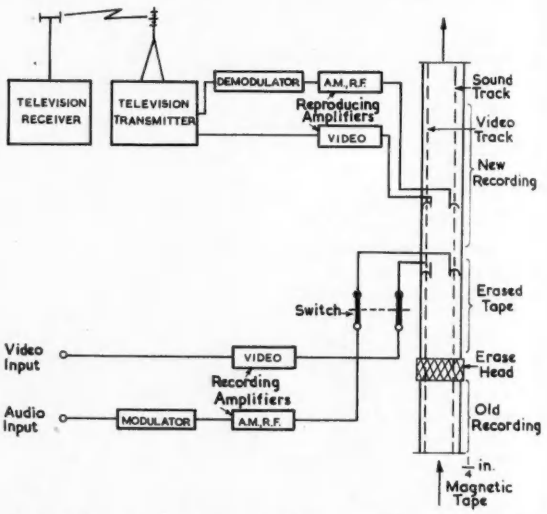


Fig. 5. The arrangement for monochrome recording and reproducing

One difference exists in the use of magnetic tape output, for here the synchronizing signals are related to the information recorded on the tape.

Video Recording and Reproducing System for Monochrome Television Signals

When black and white television signals are to be recorded only two tracks on a ¼in tape are required. As indicated in Fig. 5 one track is used to carry the complete video signal and the other is used for the associated audio signal. The signals are treated in a similar way to those already described for colour, but now the output from the reproducing amplifier is the complete video signal which, together with the demodulated audio signal, may be applied to a television transmitter, and the transmission received by conventional black-and-white television receivers.

Comparison of Photographic Film and Magnetic Tape Systems for Recording and Reproducing Television Programmes

Conventional kinescope recording is illustrated in Fig. 6.

Here the television picture is displayed on a kinescope and a special motion picture camera is used to photograph the kinescope image and record the programme sound. The film is then chemically processed, and usually a print made before the pictures can be reproduced. Reproduction requires another installation, which may be a continuous motion flying-spot film scanner or a motion picture projector with a special television camera. The process is time consuming, and the quality limited since the pictures must encounter all the hazards of both the television system and the photographic process.

Fig. 7 shows a diagram of the magnetic tape recording method which has been described. The tape requires no processing. The programme may be reproduced from the tape by using the same unit which recorded it. As in

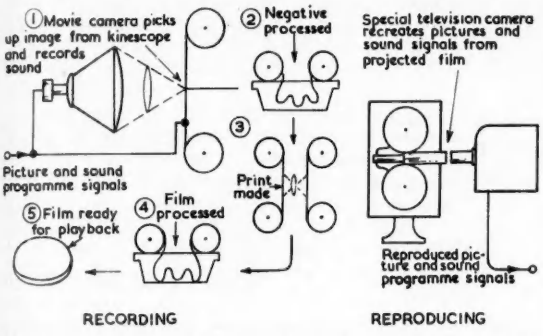

1 Movie camera picks up image from kinescope and records sound
2 Negative processed
3
Print made
4 Film processed
5 Film ready for playback
Picture and sound programme signals
Special television camera recreates pictures and sound signals from projected film
Reproduced picture and sound programme signals
RECORDING
REPRODUCING

Fig. 6. The system used for recording and reproducing a television programme by means of photographic film

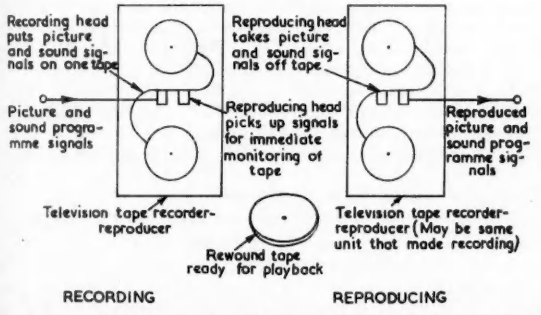

Recording head puts picture and sound signals on one tape
Picture and sound programme signals
Reproducing head takes picture and sound signals off tape
Reproducing head picks up signals for immediate monitoring of tape
Reproduced picture and sound programme signals
Television tape recorder-reproducer
Rewound tape ready for playback
Television tape recorder-reproducer (May be same unit that made recording)
RECORDING
REPRODUCING

Fig. 7. The system for recording and reproducing a television programme by means of magnetic tape

motion picture practice, when a lengthy programme is to be recorded and reproduced, a number of tape transport units with suitable switching may be used.

Comparative estimates of operating costs (which include payroll, cost of tape or film and amortization of equipment) are highly favourable to tape methods. Although magnetic tape today costs more per minute of programme time than 35mm colour film, the fact that tape needs no processing before playback compensates for the expense of raw tape, and it is clear that the magnetic tape method offers substantial economies in both time and cost.

Recording black-and-white programmes on film is estimated to be at least five times as costly as it would be on ¼ in. magnetic tape, assuming that the tape would be reused many times. This is possible since it is easy for the programme to be electronically "wiped off."

Even greater economies are estimated for making the original tape recording of colour television programmes, which under normal operating circumstances could be handled for only five per cent of the cost entailed in colour film recording.

Demonstration of Recording and Reproducing Television Signals by Means of Magnetic Tape

In the colour demonstrations at Princeton all of the programme material originated in an N.B.C. studio in New York. A similar demonstration was given in black and white. In the case of the colour demonstrations, the picture was picked up by means of an RCA colour television camera and the output fed to standard studio type video equipment to produce a composite video colour signal which was transmitted by microwave radio relay to the RCA laboratories. The sound channel used standard studio type audio equipment and the audio signal was carried by telephone line to Princeton. At the laboratories the composite colour video signal was demodulated to give the red, blue and green video signals, and the synchronizing signal, required for the input of the recording system. In reproducing the signals from the tape, the outputs of the reproducing heads were amplified and fed to a switching arrangement by means of which the direct signals could be compared side by side with those reproduced from the tape.

Two colour television receivers, each with an RCA tri-colour kinescope, were connected so that both receivers could be switched to the direct signals or both to the reproduced signals, or one receiver to the direct signal and one to the reproduced signal. As a part of the demonstration a live programme was relayed to both receivers, and during the performance one receiver was switched to the signal reproduced from the magnetic tape. The time delay introduced by the tape is the time taken to travel from the recording to the reproducing head. Since this takes only four milliseconds, the delay was imperceptible and the test demonstrated the fidelity of the magnetic system.

The status of research and engineering problems, as they relate to video tape recording, can be summarized by quoting the words of Dr. Engstrom, Executive Vice-President in charge of the RCA Laboratories Division:—

"While some technical problems still must be surmounted before video tape equipment can be made available commercially, RCA considers that the toughest of them have been conquered and that further development is certain to solve the remainder."

New Television Relay Cable

The proposed introduction of supplementary television programmes has presented a number of problems to wire relaying companies. Much work has already been done in distributing the single programme at present available and additional programmes could follow the established practice, by using a different carrier frequency. This, however, would necessitate the provision of variable tuning facilities in each subscriber viewing unit.

BICC have developed a new range of precision cables in which the crosstalk interaction has been reduced to a very low level. Using these cables, British Relay Wireless and Television Limited have engineered a television relay system capable of distributing a television programme on each pair of a screened quad cable at a common carrier frequency, thus reducing the subscriber's selective apparatus to a simple switch.

The network, now being erected to serve the area of South East London, comprises two screened quads which between them provide four vision channels on a common carrier frequency and five audio channels, the fifth audio channel being the circuit provided between the screens of the two cables.

Polythene is used for the insulation, filling, belting and sheathing of these precision quads which have plain copper conductors and a lapped copper tape screen. A feature of this new range is that the three larger cables, intended for the main distribution network of a system, have the same characteristic impedance.

The Zinc Coating of Paper for Capacitors by Vacuum Evaporation

By L. Holland* and K. Hacking*

The production of "self sealing" capacitors has been facilitated by the use of metallized paper prepared by the vacuum evaporation process. Both zinc and aluminium are commercially deposited on to capacitor tissue and it is shown that zinc can be evaporated at higher rates and at higher gas pressures than aluminium. Zinc atoms possess very low binding energies to non-metallic surfaces and it is necessary to pre-coat the paper surface with nucleating film, for example, the silver monolayer, to increase the binding energies and aid the condensation of a fine grain deposit. Zinc coatings oxidize more rapidly if deposited on to wet paper and it is advantageous to thoroughly pre-dry the paper prior to coating. The design of a degasing and zinc metallizing plant is described. The metallizing plant is capable of processing a 5 000ft length of 5in width paper in a total cycle time of 35 minutes. Interesting features of the exhaust system on both apparatus is the use of a booster diffusion pump and a gas-ballast pump.

MANSBRIDGE[1], as early as 1905, first pointed out the advantages of constructing capacitors from metallized paper. Capacitors constructed from such a foil or paper have roughly one-third the volume of their equivalent fabricated from aluminium foil and paper. It has been claimed that such capacitors possess the useful property of "self-healing" whereby the thin metal coating is volatilized and removed by arcing in the neighbourhood of an insulation breakdown either when temporarily overloaded or under normal working conditions. There has been an extensive use of metallized paper in capacitor manufacture during the last decade, largely stimulated by the need for miniature components in the electronic and communication fields. At present it is difficult to assess fully the advantages and limitations of metallized paper capacitors because there has been insufficient publication of performance data, but undoubtedly they have proved of great value where component size and weight are major considerations.

Production of zinc coated paper, prepared by vacuum deposition techniques, was first commenced in Germany[2] prior to the last war. Many capacitors were made from this paper and successfully used during the war. Also, in 1940, patents[3] were granted in this country for methods of producing aluminized foils. At the end of the war, interest in zinc coated paper was stimulated in America, and several companies[4,5] designed and constructed production plant.

In spite of the interest generally shown in metallized paper capacitors and the extensive use of zinc and aluminium coatings, there is no information in the published literature giving comparative data for the performance of these two metals when used under service conditions. The physical and chemical properties of thin coatings of aluminium and zinc are discussed below, in order to assess the relative advantages of the respective coatings when used in paper capacitors; however, the advantages claimed for a particular metal remain conjectural in the absence of experimentally determined performance data. This account is primarily concerned with the problems encountered in the metallizing of capacitor tissue in vacuo with zinc and the equipment and techniques used for obtaining sufficiently low gas pressures to enable volatile materials such as paper to be metallized. Here again, there is little useful information in the published literature, and thus the equipment described, although not novel in principle, has required considerable development investigation.

Requirements of Metallized Foil

The principal desirable properties of a metallized foil suitable for use in capacitor manufacture are that:

(1) The applied metal film is continuous and of sufficient thickness to form a good electrical conductor, but is capable of being rendered discontinuous should electrical breakdown occur in a localized area.
(2) It is uniform in thickness over the coated areas.
(3) It adheres well to the substrate, but does not penetrate it (e.g. the disadvantage found in Mansbridge foil, where the metal is sprayed on the substrate).
(4) The metal used is resistant to short-term atmospheric exposure.

In addition, it is a necessary factor in the production of such a foil that the electrical and physical properties of the substrate are not impaired by the process.

By careful design of the metallizing and associated equipment it is possible to achieve the correct working conditions for producing metallized foil having the first three of the above properties. The last, and, to some extent, the first are properties determined by the choice of metal.

A guide to plant design is best afforded by a study of the mechanism of film formation and the effects of varying the conditions under which the formation takes place.

Choice of Metal to be Evaporated

In general, the method used in producing a metallized foil is to vaporize the metal under vacuum conditions such that it condenses in the form of a thin film of uniform structure on the paper to be coated. The problem resolves into executing this process in a dynamic but controlled manner, whereby large quantities of paper are coated at economical speeds.

There are several metals which can be evaporated in vacuum on to capacitor paper, of which aluminium and zinc have found most favour on a production basis. The final choice between these metals is arrived at by considering the merits of each in relation to the production of the foil and the subsequent processing.

Suitability for the Evaporation Process

Aluminium is by far the most difficult to evaporate in large quantities economically. This is largely due to the fact that at its effective evaporation temperature ($\simeq$1 200°C) it will either chemically react or form alloys with any refractory material or metal used as a support or crucible for the molten metal. Apart from these reactions, which have been partly reduced by novel source design[6,7,8] the maximum rate of deposition is limited to relatively low values in comparison with zinc or cadmium for a given power input.

The evaporation of zinc or cadmium presents no problem of heater source reaction and, because of their much greater volatility, there are practically no source limitations on the speed at which papers can be coated. Com-

* *W. Edwards & Co. (London) Ltd.*

pare, for example, the source temperatures (1 000°C; 260°C; 340°C) necessary for Al, Cd and Zn, respectively, at which the vapour pressure is 10^{-2}mm Hg. Both in Germany[2] and America[4] speeds of 5 to 8 metres/sec have been obtained with zinc coating plant. It is not possible to form by evaporation good quality aluminium films at residual gas pressures greater than 5×10^{-4}mm Hg. Above this order of pressure the deposit develops a coarse aggregated structure lowering its electrical conductivity. The purity of the aluminium film also critically depends upon the nature and pressure of the residual gas. Thus aluminium films deposited at gas pressures as low as 10^{-4}mm Hg in a kinetic pumping system have been found to be contaminated by aluminium oxide formed by oxygen absorption during deposition. Aluminium films deposited at that pressure are, however, sufficiently compact to serve as conducting coatings, but at a pressure above 5×10^{-4}mm Hg both desirable film properties are lost, as can be observed by the discoloured and non-metallic appearance of the coatings.

In order to maintain a low chamber pressure ($\ll 5 \times 10^{-4}$mm Hg) while continuously aluminizing paper, it is necessary to pre-degas the paper thoroughly and to use very high pumping speeds to remove the water vapour which continues to be desorbed at low pressures. Thorough pre-drying of the paper is also essential, because the chemically active aluminium vapour atoms are known to react readily with water vapour either while in transit or at the condensing surface. Thus when aluminium is deposited on to wet materials, aluminium oxide is formed with the evolution of hydrogen. Aluminium is also known to form a stable nitride, and this may also be present in deposits condensed at high gas pressures. With zinc, the conditions for producing highly conducting coatings are not so critically dependent on gas pressure as with aluminium, e.g., good quality zinc films can be deposited on paper at gas pressure up to 5×10^{-1}mm Hg. As shown further on, the structure of zinc coatings depends to a great degree on the vapour intensity and the nature of the substrate surface. Very high molecular intensities may be obtained in zinc vapour beams, and it is very probable that residual gas molecules cannot easily diffuse into the interspace between the source and condensing surface and thereby become absorbed in the film during deposition. Zinc has apparently been used in preference to cadmium solely for economic reasons, otherwise the evaporation characteristics of these metals are similar.

Comparative Life of Zinc and Aluminium Metallized Capacitors

It is not easy to assess the relative merits of zinc and aluminium metallized paper for capacitor productions in the absence of comparative performance data. In view of the lower temperature required to evaporate zinc, it might be expected that 'self healing' occurs more easily and efficiently than with aluminium, since at the point of electrical breakdown more zinc would be volatilized for a given current density. Further, the oxide layer which grows on the surface of aluminium is compact and known to depress the free evaporation of the metal. During arcing it is probable that a quantity of metal oxide will be formed at the point of breakdown. In this respect aluminium should be superior, since its oxide (Al_2O_3) has exceptionally good insulation, whereas that of zinc (ZnO) has semi-conducting properties.

Thin aluminium films have the advantage of being more strongly resistant to oxidation than zinc, because they are protected by a thin but non-porous Al_2O_3 layer of some 40Å thickness. Zinc metallized paper capacitors would require suitable impregnation to prevent undue corrosion of the metal. No difficulty is experienced under controlled conditions where the capacitor manufacturer operates the coating plant, because the zinc metallized paper can be stored for a reasonable period before use, but it is improbable that the metallized paper could be marketed for winding capacitors, as is possible with aluminized paper.

Zinc, the Present Choice

To summarize, it can be said that for the production of metallized paper zinc evaporation has the following useful virtues over aluminium:—

(1) Higher coating speeds are attainable.

(2) No source reactions.

(3) No obvious deleterious effects produced in the metal film by a considerable rise in the coating chamber pressure.

Zinc Deposition Technique

Zinc contained in a suitable crucible is electrically heated in a vacuum chamber which is continuously pumped. Under these conditions metal is volatilized from its surface at a rate depending mainly on the temperature. At temperatures above its melting point (420°C) the vapour pressure of zinc rises steeply with temperature, and the vapour effusing from the crucible aperture is condensed directly to the solid state on a suitably prepared surface. If, now, the paper to be coated is passed continuously over the crucible aperture, a thin film of metallic zinc can be formed on the surface.

Critical Temperature—Beam Intensity Relation

Early experiments by R. W. Wood[9] with cadmium vapour and also by Knudsen[10] with mercury vapour showed that there exists, for a particular non-metallic receiving surface and beam intensity, a critical substrate temperature, above which condensation does not take place. This effect was interpreted by Wood as being due to reflexion of the impinging atoms when the receiving surface was held above the critical temperature. Later experiments by Langmuir [11] confirmed the existence of a critical temperature and associated critical intensity. Further, he gave strong evidence that the phenomenon was not one of reflexion but of condensation and re-evaporation, i.e., the incident vapour atoms linger on the receiving surface for a finite period. According to this theory, a vapour atom has an "average life" on a surface on which it impinges before it re-evaporates. If the "average life" of an atom is sufficiently long for a subsequent atom to arrive at the surface and adjacent to the first, so that an atom pair is formed, the energy now required, to evaporate off either of the atoms is considerably increased. This atom pair, therefore, has an even longer "average life," and so the film builds up until finally nearly all the atoms arriving are held at the surface. On this interpretation it is clear, also that the greater the number of initial atoms impinging on the substrate in a given interval of time, the greater is the possibility of forming atom pairs from vapour atoms which are mobile on the substrate. The "average life" of an initial atom depends on the latent heat of evaporation of the atom from the surface and on its temperature. For a full discussion of the dependence on the latent heat of evaporation and its influence on the structure of the condensed film, see Appleyard[12].

The "average life" of a vapour atom depends upon the temperature and nature of the condensing surface. When atoms of the volatile metals zinc, cadmium or mercury impinge on glass or other non-metallic surfaces, the forces binding the condensed atoms to the substrate are very weak, and thus, for film condensation to ensue, either the substrate must be cooled to very low temperatures, or the beam intensity must be made very high.

Pre-sensitizing with Metal Nuclei

Langmuir[11] showed that, by sensitizing the surface with nuclei of cadmium atoms formed at a temperature below the critical temperature, subsequent exposure to a cadmium vapour beam allowed a visible deposit to be formed at substrate temperatures very much above the critical temperature. This phenomenon was turned to advantage in early work on molecular beam techniques, when zinc vapour beams could be made to condense by pre-sensitizing the target with evaporated silver, which unlike zinc can be deposited using very low beam intensities. A full account of this is given by Fraser[13]. The method of artificially pre-sensitizing a surface to increase the binding energy of zinc atoms, as developed for molecular beam experiments, was applied to the zinc coating of capacitor papers in 1938 and formed the subject of a German patent[14]. An invisible deposit of a metal such as silver, copper or tin, whose atoms easily key to the surface, owing to their greater heat of evaporation, is first applied and forms the necessary nuclei for the rapid condensation of subsequent zinc atoms.

In Fig. 1 is shown a zinc metallized glass plate photographed in transmitted light. One half of the plate has been pre-sensitized with a silver deposit, of surface density equivalent to molecular thickness, and the whole area then exposed to zinc vapour. The zinc beam intensity

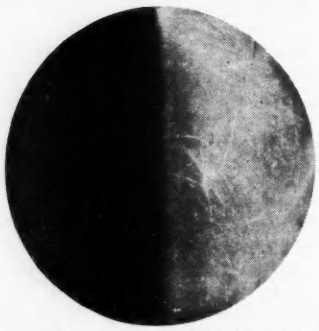


Fig. 1. A transmission photograph of zinc coated glass plate

One half has been pre-sensitized with an invisible deposit of silver and the whole exposed to a molecular beam of zinc. The deposit is seen to be denser and more uniform on the sensitized glass

was sufficient to obtain a deposit on the unsensitized area, but it can be seen that the film is not only more dense on the sensitized half, but also very uniform, whereas the film on the remaining half is not uniformly distributed but varies in density in accordance with local variation in the binding energy.

Zinc films formed on untreated paper which has not been pre-sensitized with other atomic nuclei, but by the forced condensation from a high intensity beam, are very granular and have a matt appearance. These films also have an abnormally high electrical resistivity, which is further evidence of large grain size.

Effect of Residual Gas Pressure on Film Granulation

Levinstein[15] has made electron diffraction studies of the effect of the residual gas pressure on the formation of zinc films on glass. He finds that films formed in a poor vacuum are much more uniform, and of smaller grain size, than similar films formed in a good vacuum (0·001mm Hg or less). This effect he attributes to the greater number of inter-atomic collisions that naturally occur at the higher residual gas pressures, causing the formation of aggregates of atoms in transit which, when striking the receiving surface, are more stable than single atoms. The result is a uniform spread of nuclei facilitating condensation of subsequent atoms and preventing the growth of large grains. It should be remembered that this latter effect of residual gas pressure might not be of importance when the surface is already pre-sensitized with other atomic nuclei. The authors have found that there is no directly visible difference between zinc films formed on paper at various pressures in the range 10^{4} to 5×10^{-1}mm Hg when the surface is pre-sensitized with silver.

Zinc Vapour Diffusion

At the vapour pressures required for fast coating speeds, the mean free path of zinc atoms within the vapour beam is very short. For instance, at a vapour pressure of 0·1mm Hg the mean free path may be of the order of 0·5mm which is sufficiently short to cause a certain amount of zinc vapour to diffuse throughout the coating chamber, in spite of the fact that the crucible may be designed to make the effusing molecular beam directional. This vapour diffusion creates a problem in connexion with the shielding of the spooling mechanisms and the adequate insulation of electrical lead-in terminals to the vacuum chamber. However, since the residual gas pressure need not be of a low order for satisfactory coating, the rotating components of the spooling mechanism can be lightly lubricated with low vapour pressure oils or greases. These also serve to prevent undue build-up of zinc layers on bearing surfaces. Static parts in the neighbourhood of the crucible aperture are, unfortunately, prone to be coated in the long run, and measures to facilitate the cleaning or replacement of these parts are necessary.

Methods of Providing Unmetallized Margins

For the subsequent construction of the capacitor it is necessary to provide the metallized foil with uncoated edge margins. The metal can either be removed from the foil after deposition, by an electrical burn-off technique[16,17], or prevented from condensing on certain areas of the foil during metallization. Zinc vapour will not condense on a surface which is greasy and this effect can be utilized to provide clear unmetallized bands during coating by printing the paper prior to coating, with a thin film of wax[18]. The writers have found that a low vapour pressure fluid such as a silicone diffusion pump oil also prevents zinc condensation.

Masking areas of the paper with stationary metal templates in order to prevent zinc vapour from reaching the paper is impracticable unless the accumulation of zinc on the template edges can be prevented by deliberately maintaining a contaminated surface to prevent condensation from commencing*. Also there is a tendency for zinc vapour to diffuse, as explained above, and the edge of the uncoated margin will not be sharply defined unless the paper and mask are in good contact.

An alternative scheme to the foregoing is to place a mask over the silver source to prevent a nucleating film from being condensed at the paper edge and afterwards to expose the whole of the paper surface to the zinc beam. The very low rate at which the silver is evaporated does not produce thick deposits on the mask, and a zinc film will not condense on the non-nucleated surface, i.e. providing the rate of arrival of zinc atoms at the non-nucleated paper surface does not exceed the critical value required for condensation to ensue. The rate of deposition of the zinc atoms is a function of the beam intensity and the paper speed, and at very high coating rates a granular zinc film will form on the unsilvered surface.

** It is of interest to note that scattered zinc vapour may not always condense on the water-cooled metal components of a coating jig, e.g., the water-cooled lead in electrodes, although it may condense under the same conditions on the uncooled components. It would be expected that the lower surface temperature of the water-cooled components would aid condensation, but this is offset by the fact that the cooled surfaces are contaminated by oil films condensed from the residual atmosphere in the coating chamber.*

Pre-Drying and Degasing Capacitor Paper

An important preliminary operation to the zinc metallization of the paper is the removal of a sufficient quantity of the absorbed volatile content to ensure both reasonable pressure conditions during the coating process and that the zinc is not deposited on to wet paper which would hasten its oxidation during storage. In the case of capacitor paper the absorbed volatile content is mainly water, which is held in equilibrium with the atmosphere. Murphy[19] has investigated the drying of papers and their rates of decomposition at various temperatures. Measurements made in the authors' laboratory on rolls of capacitor tissue show that absorbed water content averages 7·5 to 8·5 per cent.

The mechanism occurring in drying a porous solid which is initially in a wet state can be broken down into the following stages:

(1) Direct evaporation from a wet surface, the desorption rate being proportional to the vapour pressure of water at the surface temperature.

(2) A falling rate period during which evaporation takes place from a partly saturated surface.

(3) A final falling rate period, in which desorption completely depends on the rate at which liquid diffuses from the interior of the solid to the evaporating surfaces. If, as is usually the case, the internal resistance to diffusion is much greater than the resistance to evaporation, then moisture concentration at the surface will fall to a negligible value.

A drying mechanism of this type has been fully investigated by Sherwood[20]. The first two stages are completed fairly quickly during the drying process, and the last is found to follow Fick's law (see Barrer[21]) in the form:

$$\partial C/\partial t = D(\partial^2 C/\partial x^2)$$

where:

D is the diffusion constant in $cm^2 sec^{-1}$

C is the moisture concentration in $g.cm^{-3}$ at a distance $x$cm from the origin.

A particular solution of this equation for the case of a rigid rectangular solid drying from two opposite faces can be put into the approximate form:

$$Q_t = Q_0 . A . \exp\left(\frac{-KDt}{L^2}\right)$$

where:

Q_t = amount of volatile material remaining after time t.

Q_0 = amount of volatile material initially (i.e. at $t=0$)

L = distance between drying faces.

A and K are numerical constants.

D is the diffusion coefficient whose value depends on the absolute temperature of the solid and increases exponentially with it.

Firstly, it can be seen from this equation that complete drying implies an infinite drying time, so that from a practical standpoint the material can only be dried to a finite volatile concentration. Secondly, from Fick's law, the rate of drying depends on the concentration gradient for a fixed temperature, and the higher this gradient can be maintained, the more rapid is the drying process.

Relating these considerations to the problem of drying rolls of capacitor tissue (since it is reasonable to assume that this material, although not strictly rigid, follows similar laws), the most efficient and rapid drying will occur in vacuo when:

(1) the external gas plus vapour in contact with the paper is maintained at the lowest possible pressure.

(2) the drying temperature is the maximum possible without physical deterioration of the paper.

(3) the maximum surface area of the paper is exposed.

Pumping Systems for Degasing

In order to comply with condition (1) above, the drying chamber must be pumped by a system having sufficient speed to lower continuously the drying chamber pressure with time.

(i) *Refrigerated Systems.* This is one of the methods employed in the vacuum drying of substances containing copious amounts of water. These normally consist of a heated vacuum chamber pumped by a mechanical oil pump via a cold trap maintained at temperatures less than $-50°C$. Here an ultimate pressure of 0·01mm Hg can be attained, the residual gases at this pressure being almost entirely permanent ones, since the cold trap has a very fast pumping speed for condensible vapours.

(ii) *Non-Refrigerated Systems.* For the drying of paper it is possible to remove a great deal of the absorbed water content by pumping the drying chamber with an ordinary rotary mechanical pump. Unfortunately, without a moisture trap in the pumping line the water vapour enters the rotary pump and is condensed in the compression stage. The condensed water vapour mixing with the oil

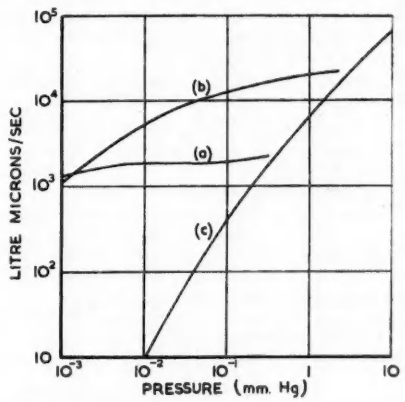


Fig. 2. Pumping characteristics of:—
(a) Edwards-type 903B oil diffusion pump.
(b) Edwards-type 9B3 "Booster" pump.
(c) Speedivac 1S450A rotary pump.

is circulated in the pump and reliberated as vapour into the vacuum system. The contamination is accumulative and results in a steady deterioration in the ultimate pressure, which seriously limits the degree of dryness obtainable.

By modifying the mechanical pump to operate on the "gas ballast" principle, whereby water vapour is prevented from condensing inside the pump, a lower ultimate pressure (approximately 0·01mm Hg) can be attained. Experiments with these pumps showed that paper dried in the rolled state for a reasonable time, even at this order of ultimate pressure, still contained an undesirable percentage of absorbed water.

In order to achieve an ultimate pressure of $\ll 0{\cdot}01$mm Hg and at the same time increase the pumping speed over the range 1mm to 0·01mm Hg, it became necessary to consider the use of special oil vapour pumps or "booster" pumps in conjunction with the mechanical pump. The specially developed vacuum pumps forming the exhaust system on the degasing unit will be described in a separate communication by the authors' colleagues responsible for their design.

For comparison purposes, Fig. 2 shows the pumping characteristics of (a) a normal vapour pump, (b) a "booster" type vapour pump and (c) a rotary oil pump. Along the ordinate is plotted the logarithm of the "through-put" in litre microns/sec and as abscissae the logarithm of the pressure in mm Hg, i.e. mass of gas exhausted per unit time at a given pressure.

From these curves it can be seen that the "booster" pump has an effective pumping speed which is some fifty to a hundred times that of the mechanical pump in the pressure range 0·2 to 0·02mm Hg, i.e. in the pressure region where moisture liberation is rapid.

A reduction in the overall drying time could be achieved by constructing an automatic continuous wind and rewind mechanism for the rolls of paper inside the drying chamber. However, for economic reasons and the fact that the width of the paper to be subsequently metallized did not exceed 5in a drying unit was constructed, utilizing the pumps described above, and the paper pre-dried in the rolled state.

Vacuum Degasing Plant

This unit consists of a long cylindrical chamber, approximately 9in inside diameter and 2ft long, with a

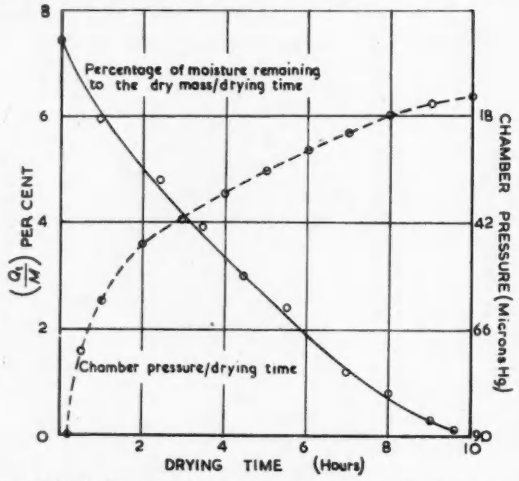


Fig. 3. The drying rate and chamber pressure for a roll of unlacquered capacitor paper (Kraft) at 70°C, indicating the performance of the drying unit

plate door at one end, mounted horizontally on a metal framework. Projecting internally from the closed end along the long axis of the chamber is a cantilever rod on which the rolls of paper are supported. Around the outside of the chamber are wrapped web type heaters, which are temperature controlled by a variable autotransformer. These heaters are capable of raising the temperature of the inset rolls from ambient to 120°C if desired. The chamber is pumped, via a high vacuum valve, by the 6in booster pump backed by a mechanical pump. A McLeod gauge and a Pirani gauge are connected to the drying chamber, so that approximate readings can be made of the total pressure of the mixture of gases and vapours (Pirani) and of the partial gas pressure (McLeod).

PERFORMANCE

Fig. 3 shows the measured desorption rate of a roll of unlacquered 9 micron capacitor tissue, 4in wide, at a mean temperature of 70°C when dried in the unit described above. The initial weight of the roll was 1 655g. Along the left-hand ordinate is plotted the water remaining, expressed as a percentage of the dry weight of the roll; and along the right-hand ordinate the chamber pressure in microns Hg, as measured with a Pirani gauge, with the time in hours as abscissae.

With paper temperatures of 100°C or greater it was observed that the drying rate increased but the partial gas pressure, as measured by the McLeod gauge, also was higher. This was interpreted as indicating a certain amount of paper decomposition with the evolution of gas plus water vapour, because Murphy[19] has observed that water vapour is formed by the thermal decomposition of paper at a temperature of 100°C or above.

For metallizing purposes, a roll of capacitor paper was considered dry when the pressures as measured by the two types of gauge were of the same order of magnitude. When the dried paper was transferred to a metallizing plant, exhausted by a 1 000lit/sec oil diffusion pump, an ultimate pressure was obtained less than 0·002mm Hg, and this value was maintained throughout the coating operation.

The drying period for unlacquered paper was found to average 8 hours. This time was considerably increased if one surface of the paper was lacquered, as would be expected, since the lacquer tends to seal one of the surfaces from which desorption takes place. If, however, a lacquer known to be impervious to moisture was used for sealing both surfaces of the tissue, then moisture desorption might be completely prevented and degasing rendered unnecessary. The lacquering technique for preventing volatile desorption has already become a routine procedure in the metallizing of cellulose acetate mouldings by vacuum evaporation[22].

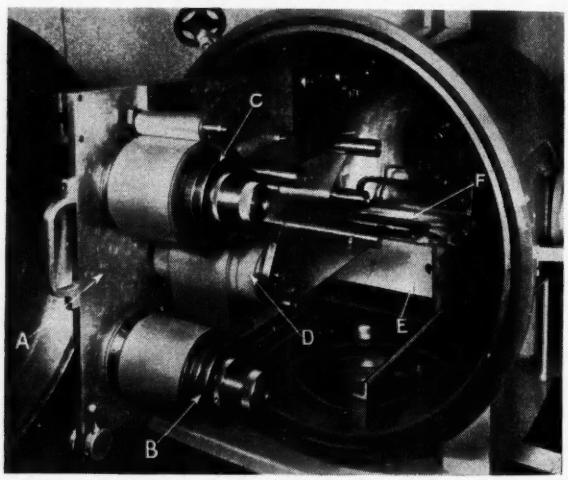


Fig. 4. Close-up of metallizing chamber, showing details of winding mechanism and sources

Metallizing Plant

PUMPING EQUIPMENT

It has already been explained that metals such as aluminium must be evaporated at greatly reduced gas pressure (less than 5×10^{-4}mm Hg) to prevent oxide contamination of the deposit, whereas highly conducting zinc films can be deposited on to nucleating films at gas pressures as high as 0·5mmHg. It is thus not essential to use a diffusion pump on a zinc metallizing plant to obtain low gas pressures as is the practice with routine vacuum evaporation plant.

However, there has been a great deal of uncertainty regarding the upper limit of gas pressure at which zinc can be satisfactorily condensed and the early models of the continuous coating equipment, described below, were evacuated, via a high vacuum valve, by a 9in diameter

silicone oil diffusion pump (Edwards 903B) having a baffled speed of a 1 000lit/sec at 0·0001mm Hg (see the speed curve in Fig. 2). The rotary oil pump for "roughing" the chamber and backing the diffusion pump operated on the "gas ballast" principle, in order to avoid contamination of the oil by any small quantities of water vapour which continued to be evolved by the paper during the coating operation. The latter pump had a free air displacement of 450lit/min. A manually operated by-pass valve was incorporated to enable the diffusion pump to be isolated from the rotary oil pump while the latter was "roughing" the chamber.

With the above pumping system a roll of capacitor paper could be coated at gas pressures of the order 2 to 3 microns Hg providing the paper had been very thoroughly pre-dried.

Further experiments have shown that high quality zinc films can be deposited at gas pressures of the order of 0·1mm Hg. In this pressure region a diffusion pump is inoperative and the 9in silicone oil diffusion pump has been replaced by a booster diffusion pump (Edwards Type 9B1) similar to that used on the degasing unit described above.

It may be considered that because of the higher operating pressure permissible the paper need not be extensively pre-dried. However, thorough drying is still essential, because firstly the zinc coating more rapidly deteriorates when stored if the moisture content of the paper is high and secondly there is an improvement in the performance of the processed capacitor.

Winding Mechanism

The paper winding mechanism is mounted inside a cylindrical chamber some 2ft in diameter and approximately the same in length, having a hinged door at the front.

The pre-dried roll of paper to be metallized is centred between the lower pair of cones B shown in Fig. 4, and the paper fed over the system of rollers to a similar take-up spool located at C. The large roller D is covered with a bonded layer of rubber and provides the driving force necessary to wind the paper. At the back of the plate (not shown) the shaft of roller D is connected to that of the take-up spool C via a friction disk clutch. The latter serves only to keep the paper taut between the two. By this method, with careful adjustments of the tension, if the drive roller is rotated with constant speed, the linear speed of the paper over the sources will remain constant, irrespective of the relative roll diameters.

The winding mechanism is coupled to a motor, mounted externally to the vacuum chamber, by a shaft rotating in a modified "Wilson" type vacuum seal. The motor has a series A.C. winding and reduction gear attachment and is speed controlled by a variable auto-transformer.

Zinc Sources

Two steel crucibles, fabricated into cylindrical form with closed ends and long jet forming apertures, hold the zinc charge which is introduced in the form of powder or wire through the apertures. The crucibles are electrically heated by means of high resistance carbon rods connected to an external low tension current supply. Each of the carbon rods dissipates above 1kW during working conditions. In order to prevent the paper from being exposed to heat radiation from the crucible walls when it passes over the vapour jets, the crucibles are shielded and enclosed in a water-cooled box E, from which only the tops of the jets protrude. (One of these can be seen at F in Fig. 4.) The water cooling system is arranged so that the inlet and outlet piping also forms the electrical connexions to the sources.

The silver source used for pre-sensitizing the paper is constructed in the form of a long carbon rod, which contains a series of pockets. Into these pockets are placed grains of silver, which, when the carbon rod is electrically heated to about 900°C, melt and form a series of evaporation sources. By this arrangement, the formation of a continuous electrically conducting channel of molten silver with the consequent shorting of the heater is prevented. This silver source is located on top of the water-cooled box E preceding the zinc vapour jets.

A sliding shutter (removed in photograph), operated externally, is arranged above the zinc vapour jets, so that the crucibles may be initially heated to the required temperature while the paper is stationary. The shutter can be moved to expose the vapour jets.

Instruments and Gauges

A thermocouple and meter is incorporated to observe the working temperature of the zinc vapour jets. There are also current meters fitted to both the independent power supplies controlling the two sources.

Provision is made to observe continuously the electrical resistance of the zinc film being deposited during the coating process. This is accomplished by passing the metallized surface over two separated metal rollers, which are electrically isolated from the base plate but connected to an external meter circuit. Since the resistance is a function of the film thickness, an indirect indication of the latter is afforded by observation of the ohmmeter deflexion.

The vacuum gauges fitted to the plant are a low pressure type Pirani gauge connected to the chamber and a normal Pirani gauge connected in the backing line.

Performance of the Plant

The capacity of the plant is limited to coating rolls of capacitor tissue not greater than 5in wide and 6in outside diameter. Using 9 micron thick tissue, this represents a length of 5 000ft and can be satisfactorily metallized in a complete cycle of about 35 minutes, including pumping and loading time. The plant is capable, using sufficiently predried tissue, of depositing a bright metallic and uniform layer of zinc having a resistance of 1-2 ohms per square. Assuming the zinc deposits to have the specific resistance of bulk material, the above values of film resistance would correspond to thickness of 0·06 to 0·03 microns respectively. Owing to the higher specific resistivity of zinc in thin film form, the thickness values will be somewhat greater.

A satisfactory coating on lacquered and unlacquered paper could be achieved using only one of the zinc crucibles, having a jet temperature of 350°C, and running the paper at a speed of 200ft/min. Speeds of the order of 500ft/min or greater are quite practical with the two crucibles in operation.

Acknowledgments

Acknowledgments are made to Mr. A. S. D. Barrett, Technical Director of W. Edwards & Co. (London) Ltd, for kind permission to publish this account.

REFERENCES

1. Brit. Patent. 19,451 (1900).
2. C.I.O.S. Report. File No. XXVII-44, Item No. 1.
3. Alexander, P. Brit. Patent 551,757 (1941).
4. Godley, P. *Iron Age* (April, 1948).
5. Wehe, H. G. *Bell. Lab. Rec. 27* (Sept. 1949).
6. Bancroft, G. H. U.S. Patent 2,584,660 (Feb. 1952).
7. Holland, L., Cutter, W. Brit. Patent 654,228 (Nov. 1948).
8. Alexander, P. Brit. Patent 485,965.
9. Wood, R. W. *Phil. Mag. 30*, 300 (915); *32*, 364 (1916).
10. Knudsen, M. Kinetic Theory of Gasses. 19. (Methuen & Co. Ltd., 1934).
11. Langmuir, I. *Proc. Nat. Acad. Sci.* (U.S.) *3*, 141 (1917).
12. Appleyard, E. T. S. *Proc. Phys. Soc. 49* Extra Part (Aug. 1937). 118.
13. Fraser, R. Molecular Beams. (Cambridge University Press, 1931).
14. Brit. Patent 510,642 (1938).
15. Levinstein, H. *J. Appl. Phys. 20*, 306 (1949).
16. Brit. Patent 647,573 (1950).
17. Brit. Patent 683,931 (1952).
18. Brit. Patent 492,681 (1936).
19. Murphy, E. J. *Trans. Am. Electrochem. Soc. 83*, 161 (1943).
20. Sherwood, T. K. *Ind. Eng. Chem. 21*, No. 1 (Jan. 1929).
21. Barrer, R. M. Diffusion in and through Solids. (Cambridge University Press, 1951).
22. Holland, L. *British Plastics*. 96 (Mar. 1951).

More about

Circuits and Logic

By T. L. Craven*, B.Sc., A.M.I.E.E.

This article pursues the theme, introduced in these columns a short while ago, of the present day impact of pure logic on the fields of technology.

IN a recent article[1] it was shown that the Boolean algebra now being used in the design of switching circuits was not by any means restricted to that field alone, but was the work of a pure logician and concerned with the analysis of processes of reasoning. Examples were given of the way in which Boolean equations used in switching circuit design could, by virtue of their generality, be interpreted in terms of statements that used everyday concepts. The object of that article was to allow circuit engineers to see Boolean algebra in its natural setting, in the belief that this would prove of interest to them and increase the facility with which they could handle its somewhat unfamiliar equations.

We shall here pursue the same theme further, examining some of George Boole's original work and seeing how he used his algebra in the symbolic enunciation of arguments. This will then raise the question as to whether, since switching circuits can be expressed in Boolean symbolism, they also can be used to exhibit the premises and conclusions of arguments. We shall find that they can indeed be so used.

The author has no particular practical application of this investigation in mind, but he believes that, with the increasing use by engineers of the concepts of formal logic, it is important to advertise these concepts and to stress their generality. There is a danger that one may come to think of Boolean algebra as a mere shorthand notation specially developed for technological applications and bearing little relationship to the world of everyday reality. Nothing could be further from the case.

The Generality of Logic

The true state of affairs may be stated as follows:—

(1) Formal logic exhibits complete generality, so that its theorems are as apt when applied to everyday things like shillings and pence as when applied to the world of fancy which treats of fairies and goblins.

(2) The same generality allows the theorems of formal logic to be applied to switching circuits.

(3) Boolean algebra is a symbolic treatment of formal logic.

(4) Boolean algebra may therefore be applied to switching circuits—and, as we now know, its application is proving to be useful.

An illustration of the first two assertions, (1) and (2), of the preceding paragraph will perhaps be welcome at this stage. Formal logic makes the common-sense assertion, for example, that a statement of the form

All A's are B's

does not of itself imply

All B's are A's

but only

Some B's are A's.

The reader will agree that *All pennies are coins* complies *Some coins are pennies*, but not *All coins are pennies*. Similarly *All fairies are immortals* implies *Some immortals are fairies* but not *All immortals are fairies*. The generality of the reasoning is exhibited by the fact that it can be enunciated in terms of abstract letters A and B. Now it is equally easy to apply it to a switching circuit. *All A's are B's* can be interpreted as *All occasions on which relay A is operated are occasions on which relay B is operated*, which suggests various circuits of which Fig. 1 is typical. (The dotted branch admits the possibility of there being some other operating circuit for relay *B*. We must show it, for otherwise we should be exceeding the original evidence and exemplifying not *All A's are B's* but *All and only A's are B's*). This circuit, constructed on the assertion *All A's are B's*, clearly implies *Some B's are A's*, that is, *Some occasions on which relay B is operated are also occasions on which relay A is operated*, but it does not imply *All B's are A's*.

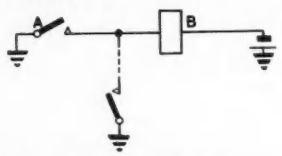


Fig. 1. Circuit representation of "All A's are B's"

George Boole and His Algebra

George Boole was an English mathematician and logician who held the Chair of mathematics at Queen's College, Cork, from 1849 to 1864. In "The Mathematical Analysis of Logic" (1847), and "An Investigation of the Laws of Thought" (1854), he introduced methods for handling the processes of formal logic in a mathematical way.

Boole starts with the concept, familiar in logic, of a "class". A class is simply a collection of all the things having some common characteristic by which the class is defined. A class is to be symbolized by a letter; thus, the class *black things* could be represented by X and the class *horses* by Y.

Next he laid down the convention that if, from any class Y, there be selected all things belonging also to some other class X, the resultant is denoted as the product class XY. In our particular case the class XY is the class *black horses*.

A further convention is that, if two classes are combined, the resultant class is denoted, appropriately enough, by addition. Thus if the class *horses* is denoted by Y, as before, and the class *cows* by Z, then the class *horses and cows* is denoted by Y + Z.

The basic symbolism is complete when three more conventions are added. The symbol "0" is used to denote a class which is devoid of members (such as the product class *carnivorous horses*). The class consisting of all things in the universe is represented by "1". And a negative class, like that of *non-horses*, is represented by (1 – Y) where Y represents the class *horses;* this is a readily accept-

* *Automatic Telephone & Electric Co. Ltd.*

able convention, for clearly the class *non-horses* is obtained by subtracting the class *horses* from that of all things in the universe.

The manipulation of these symbols is extremely simple; no operations are used other than those of multiplication and addition, and normal arithmetical rules apply in general. Evidently $X(Y + Z) = XY + XZ$ for a selection, (left-hand side), from the combined classes Y and Z of all things belonging also to the class X yields the same result, (right-hand side), as a selection from the class Y of all things belonging also to the class X combined with a similar selection from the class Z. Exceptions to normal arithmetic rules are the equations $XX = X$, $X + X = X$ and $1 + X = 1$.

$XX = X$ expresses the fact that if, (left-hand side), the class X be taken, and from it there be selected all things belonging to the class X, the resultant is still, (right-hand side), the class X.

The latter two call for more detailed comment. In the original example on the combination of two classes, we took the case of *horses* and *cows*. These are mutually exclusive, and the number of things in the class *horses and cows* is equal to the sum of the number of things in the class *horses* and the number of things in the class *cows*. But that need not always be the case and we must clear our minds of the idea of physical addition; the two classes may overlap as in the case of *vegetarians* and *quadrupeds*, where the resultant combined class *vegetarians and quadrupeds* will contain vegetarian bipeds and carnivorous quadrupeds, each of which belonged to only one of the original classes, but it will also contain vegetarian quadrupeds, which belonged to both of the original classes. $X + X = X$, then, is merely a statement of what happens in the extreme case when two identical classes are combined, while $1 + X = 1$ points out that any class X is entirely contained in the universal class " 1 ".

The Algebra in Use by Boole

A simple example of the use of Boole's algebra, which introduces one to confidence in its reliability, may be given as follows. If the four classes,

things which are both black and horses,
things which are black but not horses,
things which are horses but not black,
and things which are neither black nor horses,

be combined, the entire universe is obtained. We shall therefore expect to find that their sum, when they are symbolically expressed, is " 1 "; we shall not be disappointed, for $XY+X(1-Y) + (1-X)Y+ (1-X)(1-Y)$ does indeed equal " 1 ", as the reader may verify for himself by applying normal algebraic technique.

Of greater interest is the use of the algebra in the development of arguments. An argument familiar to all logicians, and which the reader will readily admit to be valid, is of the form

All y's are z's
All x's are y's } (premises)

$\therefore$ All x's are z's (conclusion).

It is to be noted that the two premises must have a term in common (y's in this case) if they are to be capable of leading to a conclusion. Without such a common term they would be totally unrelated and no conclusion could arise from their combination; the combination of *All men are fools* with *All geese are bipeds* leads one nowhere, but *All bipeds are fools* and *All geese are bipeds* jointly yield the conclusion *All geese are fools*. Secondly, one must note that the common term y is eliminated in the conclusion, as otherwise the conclusion would be embodying mere restatements of the premises. These facts will guide us as to our procedure in developing the argument algebraically. Let us now do that.

The premise *All y's are z's* means that no y is a non-z, so that the product class of things which are both y and non-z is devoid of members. That is, using capital letters Y and Z for the classes composed respectively of things that are y's and z's,

$$Y(1 - Z) = 0.$$

Similarly *All x's are y's* becomes

$$X(1 - Y) = 0.$$

Since Y is not to appear in the conclusion, the next step is to eliminate Y from these two equations which are simultaneously true. Normal mathematical technique is used, and the result is

$$X(1 - Z) = 0$$

which is the algebraic statement of the conclusion *All x's are z's*.

It is both gratifying and rather exciting to find that one can develop an argument in this mathematical way. A second example the reader will doubtless be able to follow with less explanation:

All z's are y's $\rightarrow$	$Z(1 - Y) = 0$	
No x's are y's $\rightarrow$	$XY = 0$	
	Eliminate Y for $XZ = 0$	$\rightarrow \therefore$ No x's are z's

Lastly, it is interesting to see how the algebra behaves if asked to deal with two premises which, despite the presence of a common term, are incapable of yielding a conclusion. The reader will see on reflexion that nothing can be elicited from, for example,

All z's are y's
All x's are y's.

Algebraically, these are

$$Z(1 - Y) = 0$$
$$X(1 - Y) = 0$$

and the elimination of Y leads only to

$$XZ = XZ$$

which is no conclusion but only a tautology. So not only will the algebra find the right conclusion where one exists, but it will in no uncertain way call a halt where no conclusion is to be found.

The foregoing is sufficient for our present purpose, but in deference to Boole it must be pointed out that it is but the beginning of his work.

The Illustration of Arguments in Terms of Switching Circuits

It is here necessary, in the interests of those readers who have not the earlier issue to hand, to recapitulate a small part of the June, 1953, article.

Switching circuits can be expressed in terms of Boolean algebra by making use of such conventions as those shown in Fig. 2; these, supported by the example shown, should be self-explanatory.

The value of such a procedure lies in the fact that it is possible to arrive at a circuit to meet specified conditions, and to effect any available simplifications of complicated circuits, by operations upon the algebra, often with considerable saving of labour.

This has been extensively discussed elsewhere, but our concern here is to interest ourselves with the question that was posed in the opening paragraphs: since switching circuits can be expressed in terms of Boolean algebra, and Boolean algebra can be used in the development of arguments, can switching circuits be used as illustrations of

arguments? The answer to the question will prove to be in the affirmative.

The first of the arguments examined was of the form *All y's are z's, All x's are y's, ∴ All x's are z's,* expressed algebraically as

$$Y(1 - Z) = 0$$
$$X(1 - Y) = 0$$
$$\therefore \text{ (on eliminating Y)}$$
$$X(1 - Z) = 0.$$

Let us first ask ourselves just what we mean by asserting that such an entirely abstract argument is valid. We mean that values may be assigned to the letters x, y and z whereupon, if conditions are such that the premises are true, then the conclusion must necessarily be true. If it is true that *All dogs* (y) *are quadrupeds* (z) and that *All spaniels* (x) *are dogs* (y), then it is true that *All spaniels* (x) *are quadrupeds* (z).

Now expressed as a circuit equivalent to the algebraic form, the first premise asserts that a circuit consisting of a normally-open contact of relay Y in series with a normally-closed contact of relay Z is always open. Fig. 3

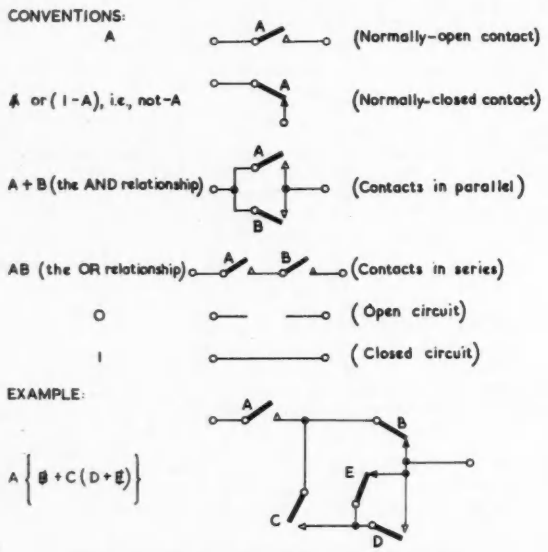


Fig. 2. Boolean algebra applied to switching circuits

(a) depicts this, and the similar treatment of the second premise and the conclusion. Applying the line of thought of the previous paragraph, then, we should hope to find that if conditions are such that the two "premise-stating circuits" are always true, then the "conclusion-stating circuit" is also always true. In other words, that any control arrangements designed solely to ensure that the two premise circuits can never provide closed paths between their terminals should be found to perform the same function also for the conclusion circuit.

Regarding the premise circuits only, then, and resolutely ignoring for the time being the conclusion circuit, we must arrange a control circuit of relays X, Y and Z such that

if Y is operated, so is Z
(for the first premise)

and also

if X is operated, so is Y
(for the second premise).

This is easily done, as is shown in the figure, and one is immediately gratified, on looking to see if the final control circuit enables one to make any deductions about a possible relatedness of X and Z, to find that it ensures the very condition necessary for the conclusion circuit, namely that

if X is operated, so is Z.

A word of comment is necessary about those control leads that are shown dotted. These leads may seem unnecessary, but not so; they are provided for exactly the same reason as was the dotted branch in Fig. 1. Considering the control circuit for the first premise, the reader will see that, in the absence of the dotted lead, the circuit would be asserting

if *and only if* Y is operated, so is Z.

This would be to exceed the available evidence, which was

if Y is operated, (but also possibly otherwise), so is Z.

To so exceed the evidence is, in logic, a grievous offence, always likely to lead one to an unjustified conclusion; this matter will be pursued further shortly.

The second argument, shown in Fig. 3(b), should present no difficulty; once again the control circuit, which has been designed solely with the premises in mind, is found to ensure also the truth of the conclusion. But it will be of some interest to see if a circuit is as perspicacious as was the algebra in the case of premises which are incapable of yielding a conclusion.

The reader will recall that the pair of premises shown in Fig. 3(c) have been shown to fall in this last category. To maintain their truth, we must have a control circuit which ensures that

if Z is operated, so is Y
(for the first premise)

and also

if X is operated, so is Y
(for the second premise).

This is soon done and then, on looking for some relationship between X and Z, we find that there is none. The circuit is, rightly, at a loss for any deduction.

Suppose, however, that in Fig. 3(c) we were to exceed the evidence by omitting the dotted leads. The first premise control circuit would now preclude the possibility of Y being operated while Z remained normal, and the second would preclude the possibility of Y being operated while X remained normal; a new final control circuit would therefore be needed. In our search for a method of combining the two premise control circuits, then, we might be tempted to proceed as shown in Fig. 3(d): that is, to reverse the order of Z and Y in the first premise control circuit, (since this makes no difference once we have omitted the dotted lead), or to resort to parallel connexion of the relays.

In either case the final control circuit implies that X and Z are always simultaneously in the same condition, operated or released, whence there would be drawn the entirely unjustified conclusion that *All x's are z's and all z's are x's,* alternatively expressed as *All and only x's are z's.*

Conclusion

It is possible that, at this stage, the reader may comment that it was quite unnecessary, in the development of arguments by means of relay controlling circuits, to have brought in Boolean algebra and its circuit equivalents. He may contend that one could equally well have derived the control circuits directly from the *verbal* premises by interpreting, for example, *All y's are z's* as *All occasions on which Y is operated are also occasions on which Z is operated* and that one could equally well have inferred the verbal conclusion in the same direct manner.

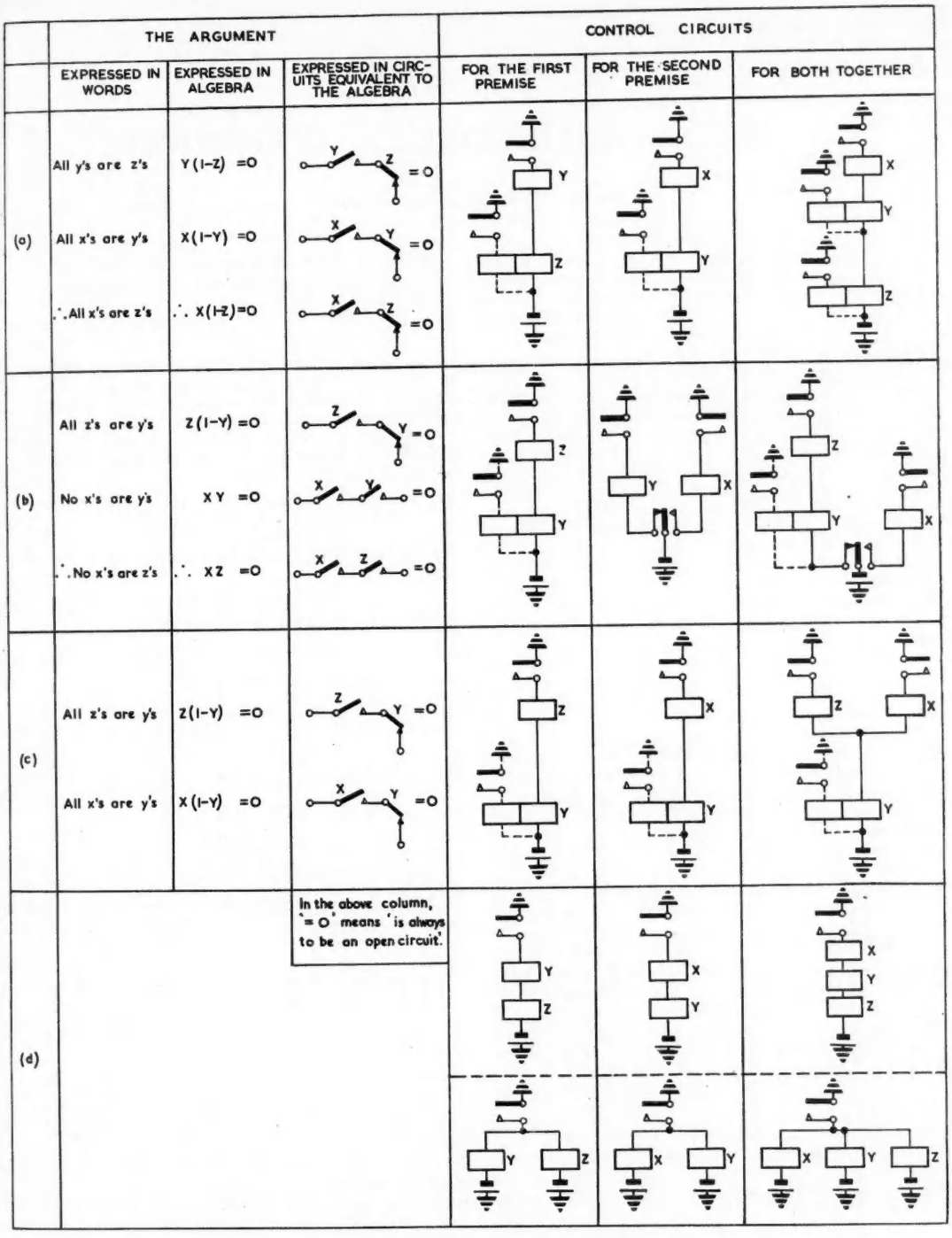


Fig. 3. The illustration of arguments in terms of switching circuits

That is perfectly true, but no one who has reached this point of view should feel any disappointment. It is just that the wheel has come full circle, so that there has emerged a clearer realization of the fact, mentioned at the outset of this exploratory article, that formal logic, switching circuits, and Boolean algebra as a tool useful to either, all form a harmonious whole.

REFERENCE

1. CRAVEN, T. L. Logic and the Circuit Designer. *Electronic Engng.* 25, 257 (1953).

Q as a Mathematical Parameter

By David Morris*, B.Sc., A.M.I.E.E.

This article illustrates a definition of Q that can be applied to RC networks and other systems having lumped parameters. The definition provides the basis upon which conventional conceptions of Q can be extended to systems having very low Q values.

THE concept of the Q of a circuit was developed at a time when interest was mainly in high-Q circuits. For such circuits, it is possible to define Q in terms of ratio of reactance to resistance, relative frequencies at "half-power" points, or ratio of energy transfer to energy dissipation. The slight discrepancies which can occur between such definitions are of little practical importance for high-Q circuits. If Q is small however, the conventional approximations are no longer valid, and the concept of Q has to be more rigidly defined if inconsistencies are to be avoided. The problem arises particularly in the fields of *RC* oscillators and of automatic control, where one may be concerned with values of Q of the order of $\frac{1}{2}$ or less. The least ambiguous concept of Q is obtained by defining it as a mathematical parameter, as in the treatment that follows.

In Fig. 1(a),

$$\frac{V_2}{V_1} = \frac{R}{1/pC + R + pL} \quad \ldots\ldots\ldots (1)$$

where $R = R_1 + R_2$ is the total resistance, and p represents the d/dt of the corresponding differential equation. Write the denominator in ascending powers of (pT), making the first term unity. Choose the time-constant T so that the coefficient of $(pT)^2$ is unity. The reciprocal of the coefficient of (pT) is then defined as Q.

Thus:

$$\frac{V_2}{V_1} = \frac{pT/Q}{1 + pT/Q + p^2T^2} \quad \ldots\ldots\ldots (2)$$

where for this circuit: $T = \sqrt{(LC)}$ and $Q = \frac{1}{R}\sqrt{\frac{L}{C}}$

Q has here been defined as a parameter in a second order denominator, and this is taken as the fundamental definition. However, the denominator is strongly characteristic of the physical system with which it is associated, and as a secondary usage one may, therefore, speak of the Q of a physical system. For example, a variety of outputs may be taken from the circuit of Fig. 1(a), with responses as follow:

$$\frac{V_3}{V_1} = \frac{1}{1 + pT/Q + p^2T^2} \quad \ldots\ldots\ldots (3)$$

$$\frac{V_4}{V_1} = \frac{p^2T^2}{1 + pT/Q + p^2T^2} \quad \ldots\ldots\ldots (4)$$

$$\frac{V_5}{V_1} = \frac{k\,.\,pT/Q}{1 + pT/Q + p^2T^2} \text{ where } k = \frac{R_1}{R_1 + R_2} \quad \ldots\ldots (5)$$

$$\frac{V_6}{V_1} = \frac{1 + (1-k)pT/Q + p^2T^2}{1 + pT/Q + p^2T^2} \quad \ldots\ldots\ldots (6)$$

It is seen that although the numerators vary markedly, the denominator is characteristic of all the responses. Defined in this way therefore, Q is characteristic of a given assembly of components, rather than of a particular output that is taken from the components. Furthermore, the definition of Q can be extended to uses for which the conventional definitions are inapplicable. Thus for the circuit of Fig. 2(a):—

$$\frac{V_3}{V_1} = \frac{1 + p(R_1C_1 + R_1C_2) + p^2R_1C_1R_2C_2}{1 + p(R_1C_1 + R_2C_2 + R_1C_2) + p^2R_1C_1R_2C_2} \quad \ldots (7)$$

and the denominator can be rewritten in terms of $T = \sqrt{(R_1C_1R_2C_2)}$

$$\text{and } 1/Q = \sqrt{\left(\frac{R_1C_1}{R_2C_2}\right)} + \sqrt{\left(\frac{R_2C_2}{R_1C_1}\right)} + \sqrt{\left(\frac{R_1C_2}{R_2C_1}\right)}$$

Thus Q can be specified for this system, even though not one of the three conventional definitions of Q applies. The response may be rewritten:—

$$\frac{V_3}{V_1} = 1 - \frac{k\,.\,pT/Q}{1 + pT/Q + p^2T^2}$$

$$\text{where } k = \frac{R_2C_2}{R_1C_1 + R_2C_2 + R_1C_2} \quad \ldots\ldots\ldots (8)$$

If the same circuit is used in a different way, as shown in Fig. 2(b), the response is

$$\frac{V_2}{V_1} = 1 - \frac{V_3}{V_1} = \frac{k\,.\,pT/Q}{1 + pT/Q + p^2T^2} \quad \ldots\ldots (9)$$

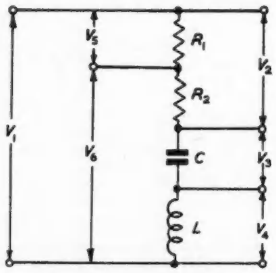


Fig. 1(a). An LRC circuit

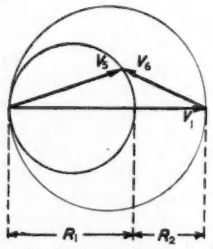


Fig. 1(b). Vector loci for Fig. 1(a)

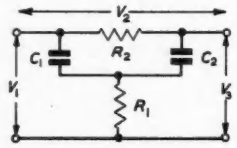


Fig. 2(a). An RC circuit for which Q cannot be defined on the "half-power" basis

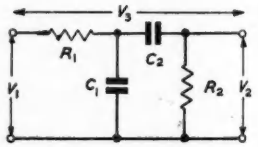


Fig. 2(b). The same circuit used in such a way that Q can be defined on the "half-power" basis

* University College of North Wales, Bangor.

If f_0, f_1 and f_2 are respectively the frequencies for maximum response and the two frequencies that give 70·7 per cent of maximum response, $Q = f_0/(f_2 - f_1)$, precisely in accordance with the conventional "half-power" definition.

Fig. 3 summarizes the properties of a variety of networks having responses as given by equation (2), while Fig. 4 shows how the same networks may be used in a different way to provide a response of the form given by equation (8). The circuits of Figs. 3(a) and 3(b) are used for feedback in servo-mechanisms, the *RC*

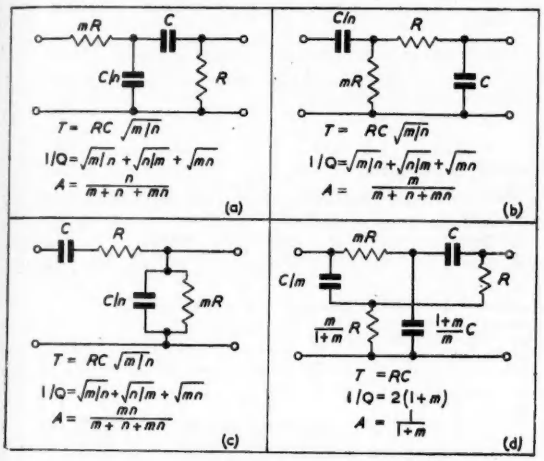


Fig. 3. Circuits of response $V_2/V_1 = A\dfrac{pT/Q}{1 + pT/Q + p^2T^2}$

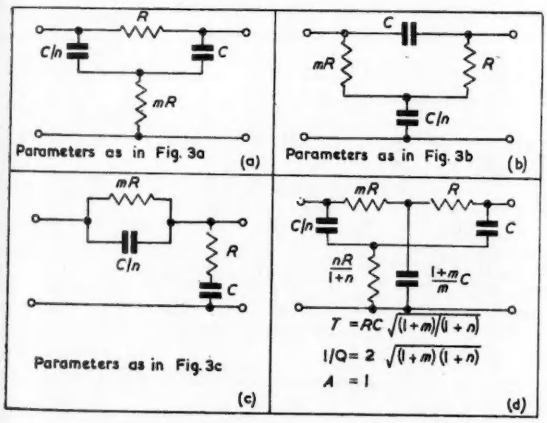


Fig. 4. Circuits of response $V_2/V_1 = 1 - A\dfrac{pT/Q}{1 + pT/Q + p^2T^2}$

section being to filter out commutator ripple while the *CR* section is to transientize the feedback. The circuits of Figs. 3(c) and 3(d) could be used for the same purpose. The circuit shown in Fig. 4(c) is used as a derivative-proportional-integral network in control systems; 4(a) and 4(b) could be used for the same purpose. Circuit 4(d) is used as a null network, and circuit 3(d) is derived from this by interchanging R and C in the output branch, and setting $m = n$. Circuits 3(d) and 4(d) have been used in combined form to provide the output and the negative feedback in *RC* wave-analysers[1]. Circuit 4(d) is frequently used in symmetrical form ($m = n = 1$), and in this case $Q = \frac{1}{4}$. By tapering the impedance level however (m and n small), it is seen that Q can be made to approach $\frac{1}{2}$. In the author's experience, Q as defined in the foregoing manner is never greater than $\frac{1}{2}$ for *RC* networks. There are also many non-electrical systems whose responses can be expressed in the forms given above.

If the circuit of Fig. 4(d) is used in the negative feedback path round a D.C. amplifier in the well-known manner (see Fig. 5(a)) the overall response is:—

$$\frac{V_{out}}{V_{in}} = \frac{\alpha}{1 + \alpha\beta}\left\{1 + \frac{\alpha\beta pT/Q'}{1 + pT/Q' + p^2T^2}\right\} \quad \ldots\ldots \quad (10)$$

where $\alpha\beta$ is the loop gain at zero frequency and $Q' = Q.(1 + \alpha\beta)$. It is not possible to define Q both simply and precisely for the complete system if any of the conventional definitions of Q is used[2]. If Q is defined as a mathematical parameter however, it can be stated that the Q of the complete system is precisely $(1 + \alpha\beta)$ times the Q of the feedback network. Properties of more practical interest can always be derived, once the form of response has been precisely defined in the above manner. For example, Fig. 5(b) illustrates the vector locus corresponding to the bracketed portion of equation (10). If the rate of change of phase with frequency is considered for the vectors AD and BD, particular interest attaches to the in-phase condition at C. For the vector AC it is apparent that the rate of change of phase is $\alpha\beta/(1 + \alpha\beta)$ times that for the vector BC. For the in-phase condition therefore, the rate of change of phase for the feedback amplifier is $\alpha\beta$ times the rate of change of phase for the feedback network.

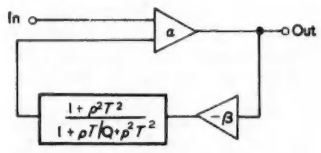


Fig. 5(a) Feedback amplifier

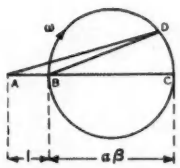


Fig. 5(b). Vector locus for Fig. 5(a)

It has in fact been proposed[2] that the rate of change of phase with frequency should be taken as a measure of Q. This type of definition has advantages in certain applications, but suffers from the disadvantage that Q is then a function of the method of using a circuit, rather than of the circuit itself. With reference to the circuit of Fig. 1(a) for example, if V_5 is the output, $Q_5 = (1/R)\sqrt{(L/C)}$ on the phase-shift definition. If V_6 is taken as the output, inspection of Fig. 1(b) shows that the Q value would be $Q_6 = Q_5R_1/R_2$, which tends to infinity as R_2 tends to zero. It will be observed that Q as defined in this way is not limited to values of less than $\frac{1}{2}$ for *RC* circuits.

The term Q has already too many uses[3], and it might be thought that an additional type of definition as proposed in this article merely aggravates the situation. However, the definition of Q as a mathematical parameter embraces most of the previous definitions, and also extends to certain aperiodic systems for which Q has been used without precise definition. The definition as proposed in this article confines the concept of Q to second order systems. It remains possible, however, to speak of the Q of each second order mode of a higher order system. If other definitions are employed, Q can certainly be "determined" for higher order systems, but has little meaning except in conjunction with a complete specification of the conditions of calculation or measurement.

REFERENCES

1. YATES, H. G. Non-Inductive Wave-Analyser Circuits of Constant Q. *Engineer.* (June 7th, 1946).
2. BROWN, D. A. H. The Equivalent Q of *RC* Networks. *Electronic Engng. 25*, 294 (1953).
3. Cathode Ray: Q—How Many Kinds Are There? *Wireless World* (July, 1949).

Multi-Channel Counter Batching

P. Huggins*, A.M.Brit.I.R.E.

A description of a technique for totalizing information from several random inputs, so that mechanical batching action may be initiated at a pre-selected total. After dealing with the general theory, a specific problem and its practical solution is described.

IN this article, counter batching is treated as an electronic technique comprising a photo-electric transducer, a multi-stage Dekatron counter, an electronic storage and an electro-mechanical batching device. This is for convenient presentation only, and is not intended as a limitation. The system outlined applies to any perception transducer, counter, storage device and batcher. In fact, the principles apply equally to an entirely mechanical counter batcher, or to any combination of physical techniques.

A multi-channel input system has two main advantages over a single channel system.

1. From a production point of view it is possible to feed into the counter batcher from several machines simultaneously, and have single line continuity of batched parts as output, thus leading to increased production.
2. From a computational point of view, it is possible to collate random information from several independent sources (and of several different kinds) and act upon a total.

Practical Considerations

Generally speaking the practical applications fall into one of two categories

(a) The information arrives randomly in every channel.

(b) The information fed into each channel arrives at approximately the same rate, but there is no correlation between channels. While in case (a) there may be an occasional coincidence of information in different channels, in case (b) there may be long periods where two or more channels simultaneously get "in-phase" information from the perception devices.

Hence, it is impractical to feed the information directly from transducer to counter. Nor is it a solution to aportion fixed time delays to each channel. To cope with the exigency of simultaneous objects some form of marshalling the information must be employed before presenting the pulses to the counter. This is conveniently carried out by memory storage methods.

In the method here described, each perception channel has its own storage unit (Fig. 1) which "remembers" the information (if any). An electronic switching device releases the information from each storage unit in rotation. Only one storage unit is "opened" at a time; all others being quiescent. It is convenient that when the storage is opened it contains either one pulse, or no pulse (i.e., an on-off mechanism). This state of affairs is guaranteed by making the frequency of the sequential switching greater than the maximum arrival rate in any channel.

* *Sargrove Electronics Ltd.*

General Description

The action of the apparatus may be summarized as follows:

Perception heads feed into their respective amplifiers, which in turn put the information pulses into storage.

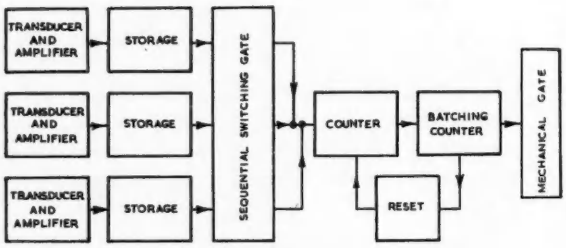


Fig. 1. The multi-channel batching counter

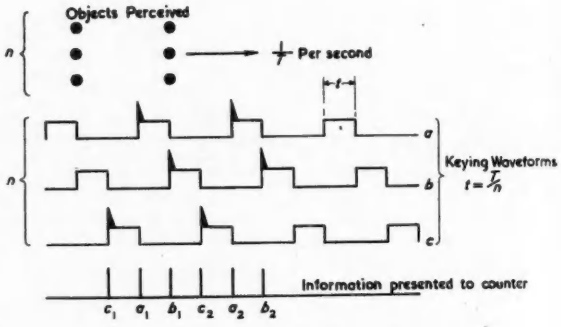


Fig. 2. Theoretical maximum information packing

A gating switch sequentially views each storage unit in rotation, abstracting the information pulse (if any) and passing it to the counter. The counter totalizes the number of impulses received and actuates the batching mechanisms on completion of the preselected batch total.

Storage Theory

The crux of the design lies in the information storage problem. Although the objects arrive randomly and discreetly, they have a mean velocity. This factor will decide the methods of mechanical handling and also the amplifier characteristics. The number of arrive channels (n) is usually predetermined by the user's site requirements. The other important parameter (T) is the minimum arrival

time interval between two consecutive objects (as distinct from their mean rate of arrival).

Fig. 2 shows a diagrammatic representation indicating the conditions prevailing when $t = T/n$ (where t is the operation time of the gating arrangement). This shows the saturation conditions that exist when the gate frequency is the reciprocal of the minimum distance between consecutive objects. In practice, this is, of course, not emulated and an empirical optimum of $t = T/2n$ has proved a satisfactory solution. However, this diagram illustrates the treatment of the coincident pulse. It will

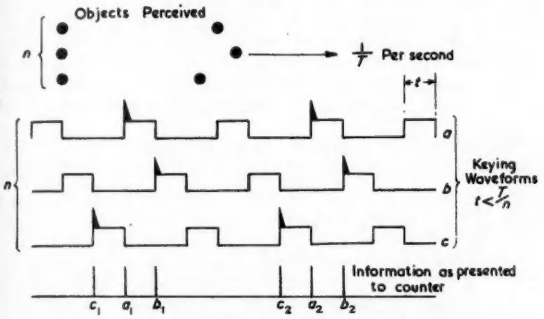


Fig. 3. Typical practical information storage waveforms

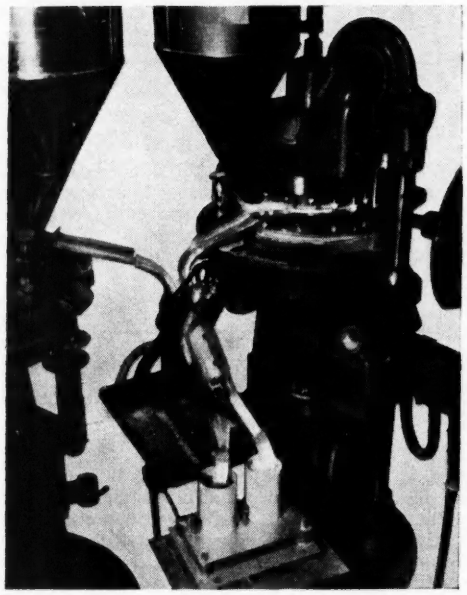


Fig. 4. Two Manesty type DB3 tablet making machines with twin batching mechanism

be observed that all three perception heads are energized simultaneously at a frequency equal to $1/T$ per second. Channel c is the first one opened after this moment of time so pulse c_1 is the first admitted to the counter. Pulses a_1 and b_1 are stored and released subsequently—the order of their going being determined by the phase relationship of the gating waveforms. The behaviour pattern is repeated T seconds later, when the three transducers are once again simultaneously excited.

A more practical case is given in Fig. 3—this corresponds to the design condition: $t = T/2n$.

Twin Channel Tablet Counting

A specific industrial problem solved on these lines will now be described.

Two tablet making machines (Fig. 4) each manufacture 300 pills per minute. It is required to count and batch these into pre-selected totals of up to 999. The minimum distance between consecutive tablets was judged to be 20 per cent of the average figure. Hence, at 300 pills per minute $T = 40$msec.

The empirical formula thus yields $t = 40/2 \times 2 = 10$ msec for a two-channel system. Since this corresponds to a half cycle at mains frequency the design can be simplified by using the mains as a time-base.

The resolution time of the counter must be better than 10msec (t) and in this application indicates the use of Dekatron valves for counting and batching.

The mechanical aspect of the tablet handling problem is best seen in Fig. 5. The pills feed down independent chutes and pass under two photo-electric transducers. From these, they pass over the ganged twin batching gates and flow into the right-hand carton. On completion of the batch number (say, 500) the batching gates flap open in

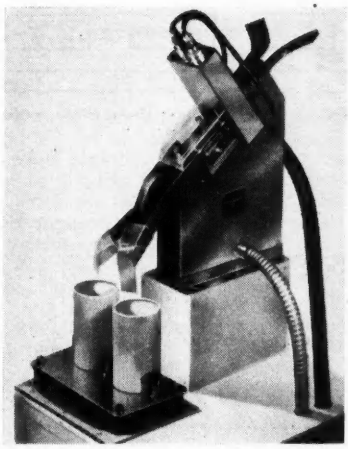


Fig. 5. Dual batching mechanism consisting of twin optical system and ganged high speed batching gates for alternate filling of cartons

the vertical plane and consequently the tablet flow is then via the lower exit chute, and thence to the left-hand carton. In this particular application the cartons are removed manually, the operator lidding and labelling the full carton, and then putting an empty one in its place while the other carton is being filled. These cartons stand on a vibrator table which assists in packing the tablets down into their containers. A further feature of the design is a suction system to extract tablet powder from the chutes, thus preventing any clogging of the mechanisms.

As a matter of interest, the potential handling power of this two-channel system (with one operator) is five times greater than the older method of single channel, single operator system without electronic batching.

Acknowledgments

The author would like to thank the directors of Messrs. Sargrove Electronics Ltd., Hounslow, for permission to publish this article, and Messrs. Wm. R. Warner Ltd., of Chiswick, Middlesex, for permission to use photographs of equipment supplied to them.

A.C. Voltage Stabilizers

By W. M. Dalton, A.M.Brit.I.R.E.

The operation of the output stage of the valve operated A.C. *mains stabilizer is analysed with the aid of load lines and the relative advantages of various modes of operation are briefly discussed.*

THE majority of voltage stabilizers are considered to operate as servo-mechanisms in which a fixed reference voltage is provided from which an error detector gives an input to be amplified and passed to a power source which bucks or boosts the supply (Fig. 1).

The difficulty of providing a reference voltage is considerably increased with an A.C. unit, for not only must the amplitude be stable, but its phase must be locked to the supply. Various types of reference-detector units have been described by Patchett and others and if merely a reference voltage is required those of Martin and Maddock[1] and

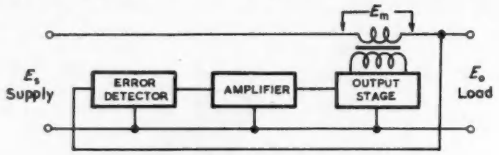


Fig. 1. Voltage stabilizer closed circuit system

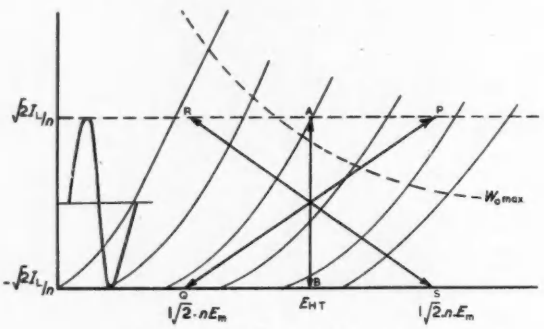


Fig. 2. Load lines on triode curves

Attree[2] slightly modified, will provide the stable low power supply.

Perhaps the only standard part of the stabilizer is the amplifier. Patchett has shown[3] that the output stage differs from a power amplifier in that, subject to the transformer ratio, the full load current flows in the valve(s) at all times. The valves provide power when boosting and absorb power when bucking. This is shown by the load lines RS and PQ respectively in Fig. 2. A single class-A stage is used for convenience, but the argument is equally applicable to the push-pull class-B stage.

It should be noted that when drawn on pentode curves (Fig. 3), the same grid swing is demanded for all load lines or the degree of buck and boost cannot be controlled by amplifying the error voltage. The triode curves are more satisfactory, but two difficulties arise at balance: firstly, with no anode voltage change the full current flows, i.e. the valve has zero resistance, and secondly a definite input is required to provide this current. At balance there should be no error to amplify and therefore no grid input.

First, however, consider another aspect. When absorbing power, the load line PQ passes beyond the maximum dissipation of the valve. It must also be remembered that the H.T. for the valves is obtained from the (unstabilized) supply and when bucking (absorbing power) the H.T. is also higher. To keep the output sinusoidal, the grid bias must also change, and with automatic bias the centres of the load lines will change as shown in Fig. 4, making the overheating worse. The same thing will happen in the push-pull stage. This can produce severe distortion on a step input change.

The improved operation from the lower r_a triode makes the cathode-follower the next logical approach. Here again,

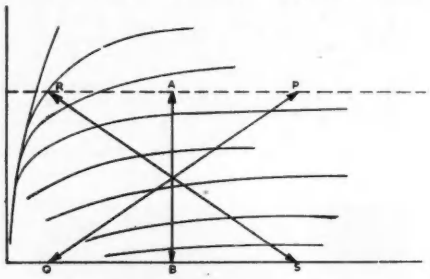


Fig. 3. Load lines on pentode

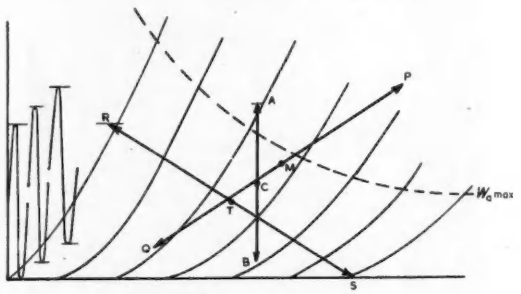


Fig. 4. Effect of changes of H.T.

although an improvement is obtained as $1/g_m$ becomes less, similar results are obtained and one comes to the conclusion that the equipment ought not to work. Another method of stabilization has been suggested[4] using the controller in parallel with the load (Fig. 5). In this case the load voltage must always be equal to the supply voltage and it is even more obvious that the system cannot work.

The parallel system could work if the input was transformed to a higher voltage (ratio $1:p$) and a series resistor (R) used to drop the voltage to that required. This circuit is shown in Fig. 6 and using the notation given in the Appendix it can be shown that:

$$R = R_o(p - 1) \quad \ldots\ldots\ldots\ldots \quad (1)$$

$$E_a = n \,.\, E_o \quad \ldots\ldots\ldots\ldots \quad (2)$$

$$\pm I_a = \pm I_o \,.\, d \,.\, p/n(p - 1) \quad \ldots\ldots\ldots \quad (3)$$

$$\pm W_a = \pm W_o \,.\, d \,.\, p/(p - 1) \quad \ldots\ldots\ldots \quad (4)$$

$$W_r = W_o(p \pm d \,.\, p - 1)^2/(p - 1) \quad \ldots\ldots \quad (5)$$

$$= [p - 1 \pm 2d \,.\, p + d^2 \,.\, p^2/(p-1)]W_o \quad \ldots \quad (6)$$

These figures for $d = 10$ per cent input variation and for

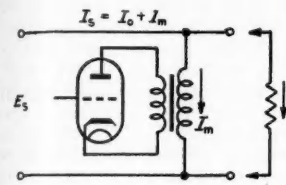
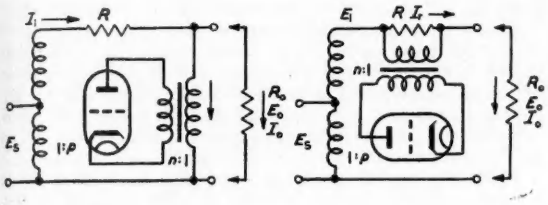


Fig. 5 (left). Shunt control

Fig. 6 (below left). Modified shunt

Fig. 7 (below right). Modified series



various values of p are given in Table 1. Here the H.T. supply at minimum supply voltage must be greater than $\sqrt{2} \cdot n \cdot E_o$, but it will be seen that for value of $p = 1{\cdot}4$ the power in the valves, when absorbing or providing power is only a third of that in the load.

Similarly values can be calculated for the series circuit, where the values of R/R_o, $n \cdot I_a/I_o$ and W_r are the same as for the parallel circuit. The important difference with this circuit is that the value of both I_a and E_a change with p. E_a varying by

$$E_a = n \cdot E_o(p - 1 \pm d \cdot p) \quad \ldots\ldots\ldots\ldots \quad (7)$$

This makes the power provided by the valve vary:

$$\pm W_a = \pm d \cdot p \cdot W_o + d^2p^2W_o/(p - 1) \quad \ldots\ldots \quad (9)$$

and the watts dissipated by the resistor are:

$$W_r = W_o(p - 1 \pm d \cdot p)^2/(p - 1) \quad \ldots\ldots \quad (10)$$

These figures for $d = 10$ per cent input variation and for various values of p are given in Table 2. It will be seen that a marked improvement in the valve dissipation is obtained. When using a step-up of $p = 1{\cdot}4:1$, the valve power at maximum buck is only 0·189 of the output power. This valve power is actually a minimum when $p = 1 \pm \sqrt{(d/(d + 1))}$.

When operating in this manner it will be seen that when bucking, the valve provides power to increase the drop in the resistor for all values of p. When boosting, however, the valve operates differently according to the value of p. When p is less than $1/(1 - d)$, the valve carries the load current and also provides power to give a reversed voltage drop across the resistor. When $p = 1/(1 - d)$ the valve carries the full load current only at maximum boost, when the anode voltage is zero. For larger values of p, the valve absorbs power, but carries less and less of the load current as p increases, giving a minimum power in the valve when $p = 1 \pm \sqrt{(d/(d - 1))}$. The load lines for $p = 1{\cdot}4$ and $d = 10$ per cent are shown in Fig. 8, where the curves show clearly that the best type of valve is a pentode in which the anode current need not change, while the voltage is swinging. It might also be noticed that the largest anode swing is required when bucking, or when the H.T. is greatest.

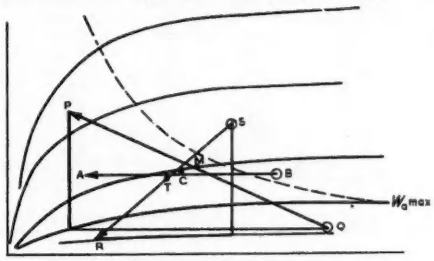


Fig. 8. Load lines

At first sight it might be thought that using the transformer will lower the efficiency of the unit. It must, however, be remembered that the control valve is operated from the supply and even in class-B, the overall efficiency —including filament power—is below 50 per cent. Assuming such an efficiency, the figures of Table 3 show that the overall efficiency is improved by using a transformer and is highest when the valve barely supplies power at maximum boost.

TABLE 1

Parallel Control ± 10 per cent input variation

p	R_d/R_o	$\pm n.\,I_a T_o$	W_a/W_o	W_r		W_s/W_o	
				High	*Low*	*High*	*Low*
1·0	0	00	00	00	00	00	— 00
1·025	0·025	4·1	4·1	0·65	0·024	5·75	— 2·86
1·05	0·05	2·1	2·1	0·48	0·055	3·58	— 1·04
1·1	0·1	1·1	1·1	0·44	0·001	2·54	— 0·099
1·2	0·2	0·6	0·6	0·51	0·032	2·11	+ 0·43
1·4	0·4	0·35	0·35	0·73	0·17	2·07	+ 0·82
1·8	0·8	0·225	0·225	1·2	0·48	2·42	+ 1·256

— W_s/W_o means that the valve supplies power to the input.

TABLE 2

Series Control ± 10 per cent input variation

p	*High Input*			*Low Input*		
	W_s/W_o	W_a/W_o	W_r/W_o	W_s/W_o	W_a/W_o	W_r/W_o
1·0	1·1	00	00	0·9	00	00
1·025	1·128	0·523	0·65	0·923	— 0·3175	0·024
1·05	1·155	0·33	0·48	0·945	— 0·1155	0·055
1·1	1·21	0·231	0·44	0·99	— 0·011	0·001
1·2	1·32	0·192	0·51	1·08	+ 0·048	0·032
1·4	1·54	0·189	0·73	1·26	+ 0·09	0·169
1·8	1·98	0·222	1·2	1·62	+ 0·14	0·48

$W_s = W_r\,W_o - W_a$ *high* or $W_s = W_r + W_o + W_a$ low.

The effect of varying the load must be considered. It can be shown that this will cause no change of E_a, but if the load current varies to $a \cdot I_o$, where a can be less or greater than unity, the anode current I_a will vary to absorb this change of current:

$$I_a = I_o(a - 1) \pm p \cdot d \cdot I_o/(p - 1)$$

This will give a greater or less dissipation in the valve but the change of current is merely in the resistor (at E_a) and the power required is considerably less than that dissipated by any attempt to maintain constant load on the unit.

TABLE 3

Operating Efficiencies
(*Efficiency* = $W_o/W_s + 2W_a$)

p	AT BALANCE (per cent)	PARALLEL		SERIES	
		HIGH (per cent)	LOW (per cent)	HIGH (per cent)	LOW (per cent)
1·0	100	zero	zero	zero	zero
1·05	96	7·2	21	47	65
1·025	91	13	31	46	85
1·1	83	21	50	60	99
1·2	70	30	62	59	85
1·4	51	40	66	52	70
1·8	31	35	59	41	53

Assuming Valves to be 50 per cent efficient.

The circuit of Fig. 7 thus provides an output stage operating in the manner originally specified. The next problem is its control.

In general there are two methods of controlling a stabilizer; the closed circuit method, shown in Fig. 1 and the open circuit control of Fig. 9, where the control is effected from the supply side. Each of these methods requires a reference voltage and an error detector, although these may be combined in the one unit.

Considering the reference voltage, this can be A.C., or D.C. An A.C. reference voltage is difficult to obtain and this must be locked to the supply frequency for supply voltage changes are usually accompanied by changes of frequency —or progressive change of phase if preferred. A D.C. reference is easily obtained, but there follows a time delay in the smoothing system and the trouble of reconverting the D.C. to A.C. Lamp bridges, saturated diodes and other devices operating on thermal effects also suffer from similar delays.

Open circuit control was abandoned by Patchett because it did not compensate for changes of load and because improved regulation and less distortion was obtained by the "feedback" of the closed circuit. The use of the series resistor, which must be adjusted to suit the load, makes the first reason invalid and one must be careful of definitions when referring to the closed circuit as a feedback system.

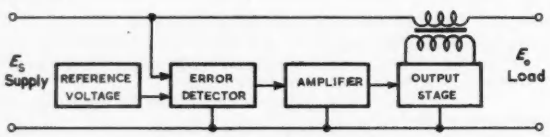


Fig. 9. Open circuit system

In the closed circuit, the voltage fed back is not a portion of the output of the amplifier, but is a portion of the error that the amplifier plus the supply voltages make with the reference voltage. As the amplifier provides only one-seventh of the power in the load even at maximum buck, it is obvious that one is feeding back from the supply rather than from the amplifier.

With the closed circuit control, except at balance, there must always be an error which can be amplified to provide the control. The gain of the amplifier has to be large in order that this fixed error shall be small. Distortion in the amplifier: 7 per cent distortion means only 1 per cent in the load and this, being wholely error, is fed back for re-amplification in a direction to buck the supply. Any harmonic distortion in the amplifier may thus be increased, being out of phase with the supply. The harmonics in the supply will provide an error in the same way, but these will be reduced by the amplifier gain. Distortion in the reference source will be faithfully reproduced.

The open-circuit control has no fixed error and the amplifier gain has only to be unity. Thus with this method a large amount of feedback can be used in the amplifier—as distinct from overall—to achieve zero gain. Distortion in this amplifier is not corrected, but is small compared with the supply and is not fed back. Distortion in the supply is reduced or suppressed provided that the reference source has a sinusoidal output. The purity of an A.C. reference source must be emphasized.

From the above it will be seen that there is little to choose between the two systems on the score of distortion. Changes of amplifier gain are usually downwards, and this gives increased stability, but a larger fixed error

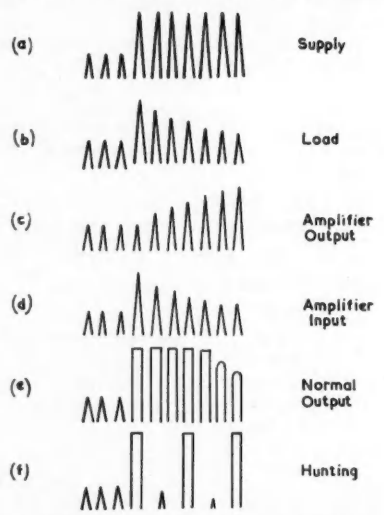


Fig. 10. Effect of step-function with closed circuit control

to the closed circuit system. This error, however, is smaller than that produced for the same change of gain when using the open circuit system. It should, however, be easier to maintain a gain of unity than one of 99 or 999 times.

The effect of changes of temperature is confined to the reference source and the error detector and provided that the amplifier is reasonably flat the effects of change of frequency should also be confined to these sources. The time of response can be a function of the source-error detector, but it can also be a function of the method of control.

Consider the action of a step rise of input to the closed circuit control. The load voltage will tend to rise to follow the step, thereby providing a large error which falls as the output bucks the supply. This is shown in Fig. 10, where (a) shows the change of supply voltage and (b) is the load voltage. The output from the amplifier must then be as in (c), while the input to the amplifier is as in (d). Obviously both (c) and (d) cannot be correct and in practice the large initial error overloads the amplifier (requiring Metrosil or other protective devices), bucking the output down to balance where a "capture" effect takes place. If the amplifier gain is excessive, and there is a delay in the error detector-convertor circuits, the output can be

bucked below balance to be followed by a boost, buck, boost in which the output varies more than the supply.

This tendency to hunt is an accepted part of the theory of servo-mechanisms where it would be due to the inertia of the load. In this case the cause is the time delay in the "differential". The absence of any tendency to hunt when using the open circuit control is perhaps a feature which outweighs the disadvantage of changes with output load.

It is possible to combine both methods, using the open circuit for supply changes and the closed circuit for load changes. As the load changes are small and infrequent, the open circuit can be made instantaneously acting while the closed circuit can have a small loop gain and an integrating circuit incorporated to delay its action and so prevent hunting.

Appendix

Symbols:

E_s, W_s = voltage and watts from supply
$d \cdot E_s$ = variation of supply voltage
E_o, I_o, W_o = volts, amperes and watts in load
E_r, I_r, W_r = volts, amperes and watts in resistor
E_a, I_a, W_a = volts, amperes and watts in valve
p = supply transformer step-up ratio
n = output transformer step-down ratio
a = fraction change of load

Parallel Circuit (Fig. 6)

At Balance:

$$E_a/n = E_o = E_s;\ I_r = I_o;\ I_a = I_r - I_o = \text{zero}$$
$$E_r = I_o \cdot R = E_o(p-1) \text{ Thus } R = R_o(p-1) \quad .. \quad (1)$$

Off Balance:

$$E_a = n \cdot E_o \quad ..... \quad (2)$$
$$p \cdot E_o(1 \pm d) = E_o + R(I_o \pm n \cdot I_a) = E_o + E_o(p-1) \pm n \cdot R \cdot I_a$$

or $\pm n \cdot R \cdot I_a = \pm d \cdot p \cdot E_o$ Substituting for R in (1) gives

$$I_a = d \cdot p \cdot I_o / n(p-1) \quad ..... \quad (3)$$
$$W_a = n \cdot E_o \cdot d \cdot p \cdot I_o / n(p-1) = d \cdot p \cdot W_o/(p-1) \quad .. \quad (4)$$
$$W_r = (p \cdot E_o \pm d \cdot p \cdot E_o - E_o)(I_o \pm n \cdot I_a)$$
$$= E_o \cdot I_o(p \pm d \cdot p - 1)[1 \pm d \cdot p/(p-1)]$$
$$= W_o(p \pm d \cdot p - 1)(p - 1 \pm d \cdot p)/p - 1)$$
$$= W_o(p - 1 \pm d \cdot p)^2/(p-1) \quad ..... \quad (5)$$

Series Circuit (Fig. 7)

At Balance:

$$E_a/n = E_o(p-1);\ I_a = \text{zero};\ R = R_o(p-1) \quad .... \quad (6)$$

Off Balance:

$$E_a/n = E_r = p \cdot E_o(1 \pm d) - E_o$$
$$= E_o(p - 1 \pm d \cdot p) \quad ..... \quad (7)$$

$n \cdot I_a = I_o - E_r/R$ and substituting for R in (6) gives

$$I_o - E_o(p \pm d \cdot p - 1)/R_o(p-1) = I_o[1 - 1 \pm d \cdot p/(p-1)]$$

or

$$I_a = \pm I_o \cdot d \cdot p / n(p-1) \quad ..... \quad (8)$$
$$W_a = Ea \cdot Ia = \pm p \cdot d \cdot W_o + p^2 \cdot d^2 \cdot W_o/(p-1) \quad .. \quad (9)$$
$$W_r = E_r(I_o \pm n \cdot I_a) = E_o \cdot I_o(p - 1 \pm d \cdot p)[1 \pm d \cdot p/(p-1)]$$
$$= W_o(p - 1 \pm d \cdot p)^2/(p-1) \quad ..... \quad (10)$$

W_a is zero when $-d \cdot p = d^2 \cdot p^2/(p-1)$

or when

$$p = 1/(1-d) \quad ..... \quad (11)$$

W_a is minimum when $\delta \cdot W_a/\delta \cdot p = 0$

$$0 = \frac{(p-1)(2d^2 \cdot p + 2d \cdot p - d) - d^2 \cdot p^2 - d \cdot p^2 + d \cdot p}{(p-1)^2}$$
$$= d^2 \cdot p^2 + d \cdot p^2 - 2d^2 \cdot p - 2d \cdot p + d$$

or when

$$p = 1 \pm \frac{\sqrt{(d^2 + d)}}{(d+1)} = 1 \pm \sqrt{(d/(d+1))} \quad ..... \quad (12)$$

References

1. Martin, D. J. R., Madock, A. J. A Low Power Alternating Voltage Stabilizer. *J. Sci. Instrum. 28* (1951).
2. Attree, V. H. A Low Voltage Stabilizer with Saturated Diode Control. *Electronic Engng. 25*, 71 (1953).
3. Patchett, G. N. A Precision A.C. Voltage Stabilizer. *Electronic Engng. 22*, 371 (1950).
4. Clapp, C. W. *Electronics* (Aug. 1950).

The Measurement of Transistor Characteristics

J. Ewels* Ph.D., A.Inst.P.

Since transistors can be permanently damaged very easily by an accidental overload, and considerable changes in their characteristics can occur through overheating or by faulty insertion in live circuits, it is essential that their performance can be rapidly checked under standard conditions. An apparatus is described with which certain network parameters, the gain and the noise factor can be rapidly measured; these parameters are defined.

Definition of Parameters

The application of four pole network theory[1] to transistors shows that the small signal properties can be uniquely determined by four independent quantities relating the instantaneous input and output voltages and currents shown in Fig. 1. The particular set of parameters used depends on the type of transistor and the method of measurement. Thus, for point contact transistors, four impedances are found to be most convenient. These are defined by the equations:

$$v_1 = R_{11}\, i_1 + R_{12}\, i_2$$
$$v_2 = R_{21}\, i_1 + R_{22}\, i_2$$

In these equations v_1, v_2, i_1 and i_2 are variables and R_{11}, R_{12}, R_{21} and R_{22} are constants. The measurement of these impedances requires the collector and emitter to be open-circuit to alternating currents and for different measurements, i.e. either i_1 or i_2 to be zero.

For junction transistors, which have high collector impedances, these conditions are impracticable and the "hybrid parameters" are more convenient. These are defined by the equations:

$$v_1 = h_{11}\, i_1 + h_{12}\, v_2$$
$$i_2 = h_{21}\, i_1 + h_{22}\, v_2$$

It should be noted that h_{11} is an impedance, h_{22} is an admittance and h_{12} and h_{21} are ratios. Measurement of the hybrid parameters requires the emitter to be open-circuit, i.e., i_1 to be zero and the collector to be short-circuit, i.e., v_2 to be zero. Further, it is important to understand that the two sets of parameters are measured,

* *E.M.I. Engineering Development Ltd.*

under different conditions, so that R_{11} is not equal to h_{11}, and R_{22} is not $1/h_{22}$.

For design purposes these parameters are not useful and it is more convenient to use the *T*-equivalent circuit shown inside the dotted lines of Fig. 1, since the resistances of this circuit are associated with the physical construction of the transistor. The relationships between these resistances and the impedances and hybrid parameters are:

$$\begin{aligned} r_e &= R_{11} - R_{12} = h_{11} - h_{12}/h_{22}\ (1+h_{21}) \\ r_b &= R_{12} = h_{12}/h_{22} \\ r_c &= R_{22} - R_{12} = 1/h_{22}\ (1-h_{12}) \\ r_m &= R_{21} - R_{12} = 1/h_{22}\ (h_{21}-h_{12}) \end{aligned}$$

These dynamic measurements are most easily made by adding a small alternating current to the D.C. bias and measuring the resultant alternating voltages and currents.

Noise Factor

A further property which it is often desired to measure is the noise factor. For this purpose an appropriate load resistor and a voltage input from a source of known impedance are required.

The noise factor[2] is given by

$$F = \frac{v_n^2}{4kTR_1\ (f_2 - f_1)\ A_v^2}$$

where v_n is the mean noise voltage measured over a bandwidth of $(f_2 - f_1)$, A_v is the voltage gain of the transistor under the same conditions, R_1 is the source impedance,

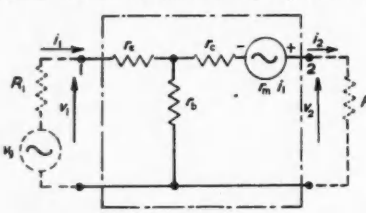


Fig. 1. Equivalent circuit of transistor

T is the absolute temperature and *k* is Boltzmann's constant.

Apparatus

The circuit diagram of the apparatus is shown in Fig. 2. In this apparatus, the bias currents are supplied from H.T. batteries through a resistor and choke; these prevent excessive leakage of alternating current to the batteries.

For D.C. measurements, the A.C. supply is disconnected by S_{1a}; for A.C. measurements $S_{1b,c}$ disconnect the D.C. voltmeters.

Switch S_2 permits a choice of input; either:

(a) a constant current can be passed through the emitter or collector or

(b) a low impedance voltage generator, in series with a predetermined source impedance R_1, can be connected to the emitter.

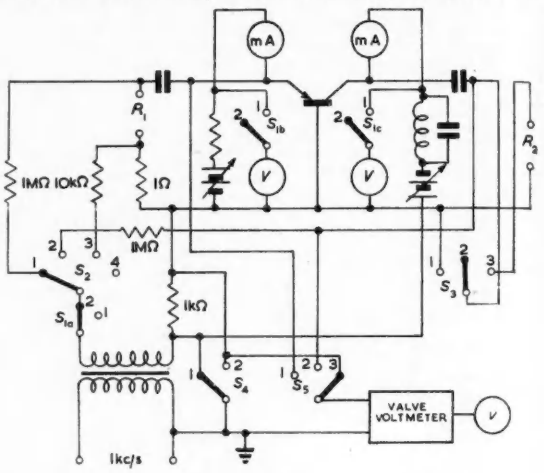
By manipulation of S_3 the load in the collector circuit can be made zero, or a nominal open-circuit (i.e., 200kΩ —the D.C. circuit impedance) or resistor R_2. The voltage at the emitter or collector, or the current flowing in the circuit selected can be measured on a valve-voltmeter by selection of the appropriate positions of switches S_4 and S_5.

Parameter Measurements

The procedure for the measurement of the impedances and hybrid parameters is shown in the table given with Fig. 2. A convenient value for the input current, when normal bias is applied, is 50μA. This is considerably larger than any noise levels likely to be encountered, but is small enough to avoid transgressing the non-linear portions of the characteristics. Impedance parameter measurements can be made to an accuracy of 3 per cent on point contact transistors whose collector impedance is less than 20kΩ.

Gain and Noise Measurements

For noise measurements a selective filter which has a bandwidth of 60c/s and a mid-frequency of 1kc/s is provided in the valve-voltmeter. Suitable values of R_1 and R_2 are 500Ω and 10kΩ for point contact transistors and 500Ω and 100kΩ for junction transistors; low noise components (wire-wound) should be used in these positions. With S_2 in position 3 the voltage gain (A_v) of the transistor may be measured by comparison of readings with S_3 in position 3 (when the reading is 1 000 × input volts) and position 2 (when the reading is the output volts). If the A.C. input is then disconnected by switching S_2 to position 4, the mean noise voltage can be read; noise factors of more than 30db may be measured in this way.



IN EACH CASE SET UP D.C. CONDITIONS WITH S_1 IN POSITION 1, THEN SWITCH S_1 TO POSITION 2 FOR A.C. MEASUREMENTS	
To measure— $R_{21}\left(=\frac{v_{21}}{i_1}\right)$ and $R_{11}\left(=\frac{v_1}{i_1}\right)$	To measure— $R_{22}\left(=\frac{v_2}{i_2}\right)$ and $R_{12}\left(=\frac{v_1}{i_2}\right)$
1. S_2 to position 1 2. S_2 to position 2 3. S_4 to position 1 4. S_3 to position 3 $\left(\text{Note } i_1=\frac{v}{1000}\right)$ 5. S_4 to position 2 6. S_5 to position 2 (Note v_2) 7. S_5 to position 1 (Note v_1)	1. S_2 to position 2 2. S_2 to position 2 3. S_4 to position 1 4. S_3 to position 3 $\left(\text{Note } i_2=\frac{v}{1000}\right)$ 5. S_4 to position 2 6. S_5 to position 2 (Note v_2) 7. S_5 to position 1 (Note v_1)
To measure— $h_{21}\left(=\frac{i_2}{i_1}\right)$ and $h_{11}\left(=\frac{v_1}{i_1}\right)$	To measure— $h_{22}\left(=\frac{i_2}{v_2}\right)$ and $h_{12}\left(=\frac{v_1}{v_2}\right)$
1. S_2 to position 1 2. S_2 to position 3 (R_3=1000Ω) 3. S_4 to position 1 4. S_3 to position 3 $\left(\text{Note } i_1=\frac{v}{1000}\right)$ 5. S_4 to position 2 6. S_5 to position 2 $\left(\text{Note } i_2=\frac{v}{1000}\right)$ 7. S_5 to position 1 (Note v_1)	1. S_2 to position 2 2. S_2 to position 2 3. S_4 to position 1 4. S_3 to position 3 $\left(\text{Note } i_2=\frac{v}{1000}\right)$ 5. S_4 to position 2 6. S_5 to position 2 (Note v_2) 7. S_5 to position 1 (Note v_1)

Fig. 2. The circuit used and the procedure for measuring parameters

Acknowledgments

The author wishes to thank the directors of E.M.I. Engineering Development Ltd., for permission to publish this article, and his colleagues for advice and useful criticism.

REFERENCES

1. SHEA, R. F. Principles of Transistor Circuits, Ch. 16 (Chapman and Hall, 1953).
2. KEONJIAN, E., SCHAFFNER, J. S. An Experimental Investigation of Transistor Noise. *Proc. Inst. Radio Engrs.* 40, 1541 (1952).

The Driven Clamp in the Presence of Noise

By P. B. Helsdon*, A.M.Brit.I.R.E.

The line by line black level clamp, as used in television systems, is discussed as an error sampling and subtraction process. The best value of the clamp time-constant is also considered.

AN error free non-composite television signal conveys information only during the picture period. There is no information conveyed during the blanking period, since it is known that it represents the black level which is a constant. If, however, the television signal is mixed with an error signal, which is low in frequency compared with the line blanking frequency, the error signal can be detected by sampling the level during the blanking period. The difference between the sampled level and the known black level is a measure of the error at that instant. This error can be stored and subtracted from the next line leaving only a residue of error, which is the change of error during that line. The lower the frequency of the error signal, the lower is its rate of change for a given waveform. Consequently this error sampling, storing and subtraction system works best for low frequency error signals.

The operation of error detection, storage and subtraction is combined in the "driven clamp" circuit shown in Fig. 1. An idealized form of the clamp is shown in Fig. 2 where the diodes are represented by a switch and a single resistor represents the previous anode load and the diode impedances, etc.

Consider first the operation of the circuit (Fig. 2) under error free conditions. The input consists of a noise- and error-free television signal. During the blanking period the signal level at the input is zero. When the switch is closed for the sampling period (within the blanking period) there is, therefore, no potential to charge the capacitor. During the picture period, the switch is open and the clamp time-constant becomes very large so that picture signals at the input pass through the capacitor to the output unchanged. A constant D.C. potential added to the input causes the capacitor to charge through the resistor during the sampling periods, to a potential equal to the added D.C. When steady state conditions prevail the equal potentials cancel at the output and so the added constant D.C. may be neglected.

When a low frequency error signal is added to the noise-free television signal, the level at the input is no longer zero during the sampling period. Consequently the capacitor charges through the resistor during this period. If the time-constant of the circuit is small compared with the sampling period, the capacitor charges to a potential equal to the error signal at that time. This charge is stored throughout the picture period. The signal at the output then consists of the sum of the television signal, the error signal and the potential due to the stored charge on the capacitor. This stored potential is in opposition to the error signal, so these cancel, leaving only the television signal and the change of the error signal during the picture period. With the clamp time-constant equal to the sampling period though, the capacitor is charged to only 62 per cent of the error potential, leaving 38 per cent to be corrected. A relatively constant error signal is therefore corrected in steps, the steps becoming negligible more rapidly for a shorter clamp time-constant. When the clamp time-constant is one third of the sampling period an error is reduced to 5 per cent at each sample.

If the television signal contains noise the black level established by the clamp becomes subject to a noise error due to the non-zero value of the noise during the sampling period[1]. This noise error is also stored in the capacitor during the picture period. Should the signal-to-noise ratio in the television signal be low, this noise error can be greater than the error signal, thus defeating the object of the clamp. The magnitude of the noise error for a given signal-to-noise ratio is dependent upon the relative values of the clamp time-constant, the sampling period and the reciprocal of the noise bandwidth. When the sampling period is not long compared with the reciprocal of the noise bandwidth, involved statistical laws come into play. In practical clamps the sampling period is long, so that the noise bandwidth can be neglected and the analysis simplified. The maximum initial noise error for a given noise pulse develops when the noise pulse occurs at the end of the sampling period. The same noise pulse occurring earlier in the sampling period causes less noise error. For example, if the noise pulse is assumed to be rectangular with a duration equal to the clamp time-constant and the sampling period is three times this, the noise error will be 62 per cent of the noise pulse amplitude when the noise pulse occurs in the last third of the sampling period, but when the same noise pulse occurs in the first third the noise error is only about 10 per cent.

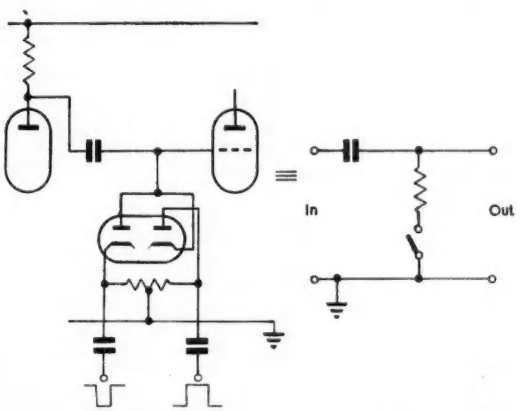


Fig. 1. The "driven clamp"

Fig. 2. An idealized clamp

Now with wideband random noise of uniform spectrum, a noise pulse of given amplitude and duration has equal probability of occurrence at any time. Therefore for a given clamp time-constant the initial noise error is independent of the sampling period, although as seen above, the number of steps required to reduce the initial noise error to a given fraction is dependent upon the ratio of the sampling period to the clamp time-constant. The initial noise error is less for a longer clamp time-constant, but for a given sampling period, a greater number of steps are required to reduce it to a given fraction.

The sampling period is limited to the duration of the blanking interval, or it may be less depending upon other considerations. The value of the clamp time-constant must therefore be a compromise between the number of steps required to reduce a relatively constant error signal to negligible proportions and the noise error introduced through sampling the noise in the signal. The best compromise value depends upon the visibility of the various error signals in the displayed picture and is a subjective consideration.

* *Marconi's Wireless Telegraph Co., Ltd.*

REFERENCE

1. Bibliography. Proc. I.R.E. 1544 (Dec., 1947.)

A Simplified Circuit and Conductimetric Tube for Chemical Analysis at Low-Frequency

By G. G. Blake*, F.Inst.P., M.I.E.E.

This article describes a circuit in which transformers are replaced by a single iron-cored choke and capacitors. Protection to operation is provided by limiting resistances. A formula for dipper calibration is given and a new and more accurate method of solution measurement and delivery "Dipper draining" is described.

A new type of "Conductimetric tube" displaces the usual "conductivity cell"; this can be immersed in any quantity of solution. An adjustable resistor standard is described, also a tubular solution container which, making use of liquid displacement, requires only 10cm³ of solution for titrations, etc.

THE circuit arrangements described are designed for A.C. operation. While equally effective as other A.C. methods in obviating the cumulative action of polarization and for accuracy in general use, they provide an inexpensive and simplified method for conducting electro-chemical analysis and titration.

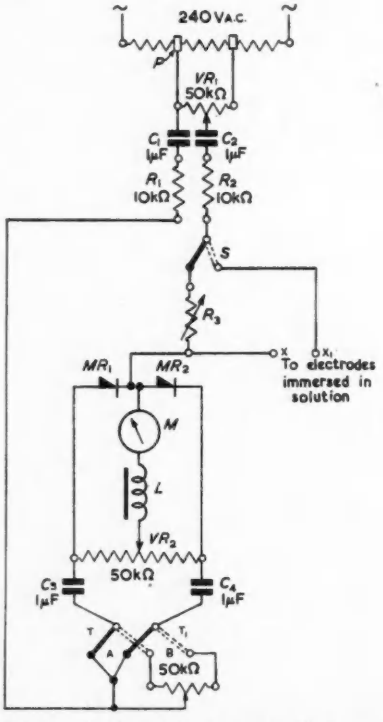


Fig. 1. Simplified A.C. circuits for chemical analysis, titration, measurements of concentration, etc.

When operated by the B circuit the opposing currents from MR_1 and MR_2 are slightly unbalanced to provide the required micro-amperage.

A potential divider displaces the usual step-down transformer and a single iron-cored choke and capacitors take the place of a transformer specially wound to match the microammeter.

The circuit shown in Fig. 1 can be employed for the measurement and comparison of solution concentrations, for titration and to observe delayed chemical reactions, etc. The author has employed it recently to compute the cubic delivery capacity of dippers and microdippers[1,2] and afterwards to compare their calibrations with those obtained by rectified radio-frequency[2]. The circuit presents several new features. The mains voltage after suitable reduction by a potential divider P is finely regulated by means of a potentiometer VR_1. C_1 and C_2 are two $1\mu F$ capacitors. R_1 and R_2 are two $10k\Omega$ resistors; these are provided to limit the current and ensure the safety of the operator.

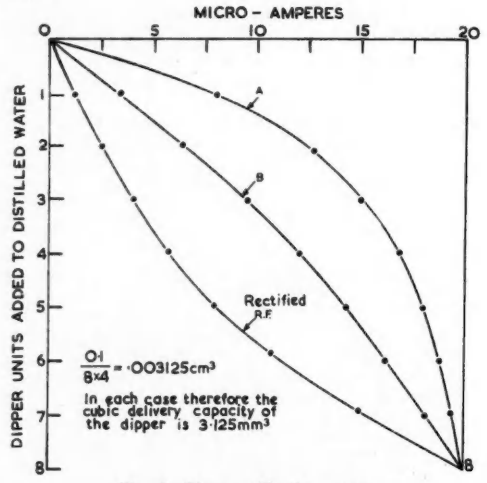


Fig. 2. Dipper calibration curves

R.R.F. was plotted by rectified radio-frequency, and A and B by low frequency methods. In all three cases it took 8 units of N/1 HCl to make up a 0·25 per cent mol solution.

S is a switch by means of which either the terminals X and X_1 may be connected to the electrodes (of a standard conductivity cell or conductimetric tube) or alternatively to a variable resistor R_3. MR_1 and MR_2 are two small metal rectifiers. M is a microammeter reading 30-0-30. An iron-cored choke L prevents A.C. from passing through the meter. The D.C. from the rectifiers (which are connected in opposition) is balanced as required by means of a potentiometer VR_2. C_3 and C_4 are $1\mu F$ capacitors; A and B are alternative circuits, the purpose of which becomes clear by comparing curves A and B, Fig. 2.

Dipper Calibration

A simple formula for dipper calibration has been given[1] and from this the following method has evolved.

* *University of Sydney. Dept. of Chemistry.*

(1) A meter deflexion is first obtained for a 0·25 per cent mol solution of HCl (this may be given any value desired—say 20μA).

(2) The HCl solution is then replaced by 10cm³ of distilled water to which (one by one) dipper units of N/I HCl are added until the meter deflexion is 20μA, i.e. the same as that for the 0·25 per cent mol solution.

(3) Where a is the number of dipper units which were added to 10cm³ of water $0{\cdot}1/42$ = the delivery capacity in cubic centimetres.

Fig. 2 reproduces calibration graphs for the same dipper plotted by circuits A and B, Fig. 1. Both discover the same number of units, i.e. 8 for 0·25 per cent mol solution of HCl. The straighter of the two curves gives a more evenly distributed spacing, particularly at the 20μA end of the curve and is therefore preferable for dipper calibration.

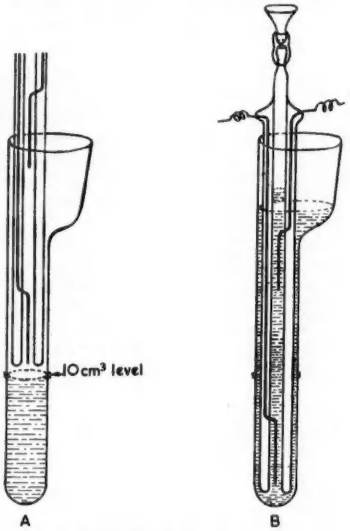


Fig. 3. A low-frequency conductimetric tube with internal electrodes as used when calibrating the dippers.
Note how the liquid rises in the tube as it is introduced into the container.

As the circuits shown in Fig. 1 entirely avoid the cumulative effect of polarization at the electrodes there is no longer a necessity to employ a standard conductivity cell having platinized platinum electrodes. For most purposes tungsten electrodes may now be used.

Instead of using a cell the conductimetric tube shown in Fig. 3 may be employed, designed on the lines (except that its electrodes contact the solution) of that described in Ref. 2, whereby the electrolytic resistance of only a column of the solution is measured. This general purpose A.C. conductimetric tube was employed to plot the dipper calibration curves here reproduced.

When the tube is inserted into a test-tube containing 10cm³ of distilled water the latter rises well above the upper electrode and both electrodes are submerged.

It was found convenient to enlarge the mouth of the test-tube sufficiently to allow for insertion of the dipper, and the addition of a funnel at the top of the conductimetric tube to facilitate the washing out of the tube from time to time during operations.

The conductimetric tube can be used, of course, with a solution container of any size given sufficient depth to cover its upper electrode. The same dipper was then calibrated by the rectified radio-frequency method. In this case the conductimetric tube was fitted with external electrodes[2]. As seen from Fig. 2, complete agreement was obtained. This result is important as it demonstrates that for all practical purposes in both R.R.F. and A.C. methods we are measuring the same thing, i.e. the electrolytic resistance of the solution. It is evident that the small changes in dielectric constant which must occur in the former case are too small to detect. This is confirmed also by the titration graphs in Fig. 4, plotted respectively by the A and B A.C. circuits (Fig. 1) and by the R.F. method[2]. All three methods discover the same end point, viz. 6 dipper units. In this case the dipper had a delivery capacity of 4·18mm³. From these graphs it is seen that the A circuit is better suited for titration than the B.

The Use of the Adjustable Resistor R_3 (Fig. 1)

Having selected a meter deflexion for any particular solution concentration it is useful to substitute an equivalent resistor R_3 for reference instead of the standard solution. In this way time and trouble is saved.

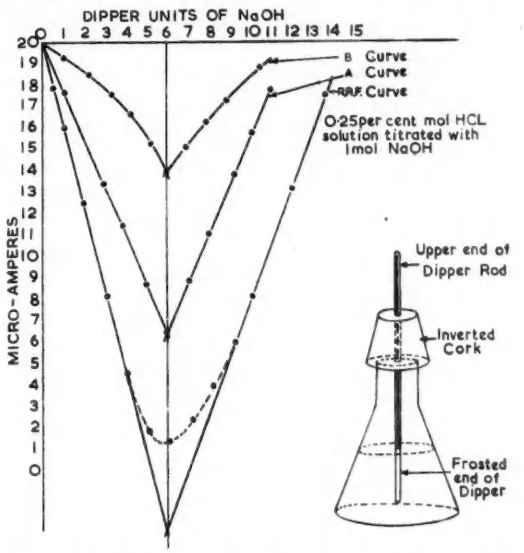

DIPPER UNITS OF NaOH
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
MICRO-AMPERES
20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
B Curve
A Curve
R.R.F. Curve
0·25per cent mol HCL solution titrated with 1mol NaOH
Upper end of Dipper Rod
Inverted Cork
Frosted end of Dipper

Fig. 4. The titration of a 0·25 per cent mol HCl solution by N/I NaOH.
Note that the R.R.F. *and* A *and* B A.C. *graphs all discover the same end point.*
Inset. Showing a frosted glass dipper rod inserted through an inverted cork
This ensures the same depth of immersion upon replacement after each withdrawal.

Dipper Transfer

There are two procedures which may be followed when transferring quantities of a liquid by dippers.

(1) For rapid work, provided that care is taken, the dipper can be immersed in N/I solution and the whole amount of the liquid which it picks up transferred directly to the solution under test. Or

(2) After the dipper has been immersed in the N/I solution it can be drained by touching its lower end against the surface of a sheet of filter or blotting-paper before it is introduced into the solution.

Although the amount transferred by this method is smaller, greater accuracy is obtainable. Drained dippers were used for all the curves reproduced in this paper. Fig. 4 is a sketch of a frosted glass dipper when immersed to the correct depth in a bottle of 1 mol HCl.

REFERENCES

1. BLAKE, G. G. Surface-Tensional Methods for Measuring and Delivering Minute Quantities of Liquids. *Metallurgia. 41* (May, 1950).
2. BLAKE, G. G. Conductimetric Analysis at Radio-Frequency. (Chapman & Hall, London).

Oscillator Feedback Networks

of Minimum Attenuation

By P. W. Ward*, B.Sc., A.M.I.E.E.

A single valve RC oscillator with feedback network consisting of three equal resistors and three equal capacitors requires an amplifying stage with gain exceeding 29. It is known that this gain may be reduced if unequal component values are used. In this article a method of determining optimum values is proposed.

THE networks discussed in this article are of the two basic types involving three phase-shifting stages which are generally used with a single valve for fixed frequency operation.

Oscillators involving those networks were first proposed by Nichols some thirty years ago, and have since been the subject of much literature and controversy. While therefore some preliminary remarks are considered necessary to clarify the situation, it is not intended that the subsequent discussion should be related to past controversies.

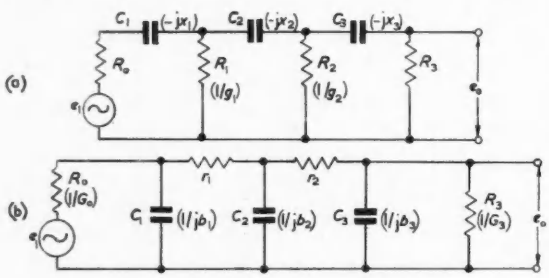


Fig. 1. Three-stage feedback networks

These oscillators have applications in modern equipment as very light and compact sources of audio frequency signals. A practical disadvantage is that while a certain value of gain is required to maintain oscillations, excessive gain causes distortion. Stability of gain is therefore an important design consideration if the oscillator is to function without attention for the normal life of the valve. Such stability is most readily obtained in conjunction with minimum attenuation in the phase shifting network.

It is proposed to consider the networks of Figs. 1(a) and 1(b), to show that at any one frequency duality exists between these networks, and to deduce expressions which will allow component values to be chosen for either network to give minimum attenuation.

With the first network it is usual to consider $R_1=R_2=R_3$ and $C_1=C_2=C_3$. Many designers neglect the output resistance R_o of the valve. The resistance R_o of the second network usually consists of a resistance equal to r_1 and r_2 in series with the amplifier output resistance, while $C_1=C_2=C_3$. The input resistance R_3 of the valve with its grid leak is almost invariably ignored. The attenuation factor, $-e_1/e_o$, of either of these networks with equal resistors and equal capacitors must be greater than 29.

Several references exist to a system of staggering to reduce the attenuation. This reduction is based on the principle that if each phase shifting stage could be made of so much higher impedance than the preceding stage that it would impose negligible loading, the attenuation factor would approach 8. Extensions of this arrangement applicable to finite values of the ratio $R_3:R_o$ have been analysed in some detail with the aim of designing networks of reduced, but not minimum, attenuation.

* *The General Electric Co., Ltd., England.*

Determination of Optimum Values

A satisfactory design requires the determination of values for the components of the networks of Figs. 1(a) and 1(b) which give minimum attenuation with the conditions that R_o and R_3 have predetermined finite values and that the phase shift of the respective networks should be $\pm\pi$ at a selected frequency.

The notation of impedance and admittance shown in Fig. 1. has been chosen to avoid unduly cumbersome algebraic expressions. Small letters are used for quantities considered variable in the mathematical sense. In order that the calculation may be presented reasonably briefly, it will be assumed that at least one set of conditions giving minimum attention can exist. Justification of the assumption that an expression has finite value will be omitted where this is fairly obvious; also those stages which involve only manipulation of the elementary trigonometrical identities will be omitted.

Application of Kirchhoff's laws to the network of Fig. 1(a) gives the following results:

$$R_3 \mathscr{R}\, e_1/e_o = R_o(1 + g_2 R_3) + R_3(1+g_1 R_o) - x_1 x_3 (g_1+g_2) - x_2 [g_1 x_1 (1+g_2 R_3) + g_2 x_3 (1+g_1 R_o)]$$
$$= \mu_1 - \mu_2 x_2, \text{ say, } \ldots\ldots\ldots (1)$$

$$R_3 \mathscr{I}\, e_1/e_o = -x_1(1+g_2 R_3) - x_3(1+g_1 R_o) - g_1 x_1 R_3 - g_2 x_3 R_o + x_2 [g_1 g_2 x_1 x_3 - (1+g_1 R_o)(1+g_2 R_3)]$$
$$= \mu_3 + \mu_4 x_2, \text{ say, } \ldots\ldots\ldots\ldots (2)$$

Hence for a phase advance of π, $R_3 \dfrac{e_1}{e_o} = \mu_1 - \dfrac{\mu_2 \mu_3}{\mu_4}$ (3)

Similar analysis of the second network shows:

$$G_o \mathscr{R}\, e_1/e_o = G_3(1+r_1 G_o) + G_o(1+r_2 G_3) - b_3 b_1 (r_2+r_1) - b_2[r_2 b_3 (1+r_1 G_o) + r_1 b_1 (1+r_2 G_3)] \ldots\ldots\ldots (4)$$

and

$$G_o \mathscr{I}\, e_1/e_o = b_3(1+r_1 G_o) + b_1(1+r_2 G_3) + r_2 b_3 G_o + r_1 b_1 G_3 - b_2[r_2 r_1 b_3 b_1 - (1+r_2 G_3)(1+r_1 G_o)] \ldots\ldots (5)$$

The duality of the two networks is now evident, the difference of sign of the imaginary parts signifying difference of sense of phase-shifts. The first network only will be considered, and the duality will be used to obtain corresponding results for the second network.

Partial differentiation of the expression $\mu_1 - \dfrac{\mu_2 \mu_3}{\mu_4}$ with respect to g_1, g_2, x_1 and x_3 would yield four equations whose solutions would give the optimum values of the four variables. Although such a method would not be practicable, it is convenient to consider here the results of partial differentiation of the expression with respect to g_1 and g_2. It follows that for the required conditions:

$$\mu_4^2 \frac{\partial \mu_1}{\partial g_1} - \mu_2 \mu_4 \frac{\partial \mu_3}{\partial g_1} - \mu_3 \mu_4 \frac{\partial \mu_2}{\partial g_1} + \mu_2 \mu_3 \frac{\partial \mu_4}{\partial g_1} = 0$$

and

$$\mu^2_4 \frac{\partial \mu_1}{\partial g_2} - \mu_2\mu_4 \frac{\partial \mu_3}{\partial g_2} - \mu_3\mu_4 \frac{\partial \mu_2}{\partial g_2} + \mu_2\mu_3 \frac{\partial \mu_4}{\partial g_2} = 0$$

But $$\frac{\partial \mu_1}{\partial g_1} = \frac{\partial \mu_1}{\partial g_2} \text{ and } \frac{\partial \mu_3}{\partial g_1} = \frac{\partial \mu_3}{\partial g_2}$$

$$\therefore \mu_4 \left(\frac{\partial \mu_2}{\partial g_1} - \frac{\partial \mu_2}{\partial g_2} \right) = \mu_2 \left(\frac{\partial \mu_4}{\partial g_1} - \frac{\partial \mu_4}{\partial g_2} \right)$$

$$\therefore \mu_4 [x_1 (1+g_2R_3) - x_3 (1+g_1R_0) - g_1x_1R_3 + g_2x_3R_0] = \mu_2 [R_3 (1+g_1R_0) - R_0 (1+g_2R_3) - x_1x_3 (g_1-g_2)] \quad (6)$$

Referring now to equations (1) and (2), let $g_1R_0 = a\cos\alpha - 1$, $g_2R_3 = b\cos\beta - 1$, $g_1x_1 = a\sin\alpha$, $g_2x_3 = b\sin\beta$. The corresponding substitutions for equations (4) and (5) are

$r_2G_3 = a\cos\alpha - 1$, $r_1G_0 = b\cos\beta - 1$, $r_2b_3 = a\sin\alpha$, $r_1b_1 = b\sin\beta$.

Since now $\mu_2 = ab\sin(\alpha+\beta)$ and $\mu_4 = -ab\cos(\alpha+\beta)$, it follows from equation (3) that:

$$R_3\, e_1/e_0 = \mu_1 + \mu_3 \tan(\alpha+\beta)$$

$$= \sec(\alpha+\beta) \left(bR_0 \frac{a-\cos\alpha}{a\cos\alpha - 1} + aR_3 \frac{b-\cos\beta}{b\cos\beta - 1} \right) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (7)$$

For minimum attenuation, $\partial/\partial a\,(R_3\, e_1/e_0) = 0$

$$\therefore bR_0 \frac{\sin^2\alpha}{(a\cos\alpha - 1)^2} = R_3 \frac{b-\cos\beta}{b\cos\beta - 1} \quad \ldots\ldots\ldots\ldots \quad (8)$$

Similarly $$aR_3 \frac{\sin^2\beta}{(b\cos\beta - 1)^2} = R_0 \frac{a-\cos\alpha}{a\cos\alpha - 1} \quad \ldots\ldots \quad (9)$$

Also for minimum attenuation $\partial/\partial\alpha\,(R_3\, e_1/e_0) = 0$

It follows from equation (7) that

$$R_3\, e_1/e_0 \sin(\alpha+\beta) + bR_0 \frac{(a^2-1)\sin\alpha}{(a\cos\alpha - 1)^2} = 0 \quad \ldots\ldots (10)$$

By symmetry, considering the condition that

$$\partial/\partial\beta\,(R_3\, e_1/e_0) = 0$$

$$bR_0 \frac{(a^2-1)\sin\alpha}{(a\cos\alpha - 1)^2} = aR_3 \frac{(b^2-1)\sin\beta}{(b\cos\beta - 1)^2} \quad \ldots\ldots\ldots \quad (11)$$

Equations (8) to (11) contain sufficient information for the evaluation of a, b, α and β in terms of R_0 and R_3, but are not readily solved directly. Equation (6) however has a "catalytic" effect. By substitution and simplification, equation (6) may be reduced to

$$bR_0 \frac{\sin\alpha}{a\cos\alpha - 1} = aR_3 \frac{\sin\beta}{b\cos\beta - 1} \quad \ldots\ldots\ldots\ldots \quad (12)$$

Elimination of b from equations (8), (9) and (12) yields

$$(a^2+1)\sin(\beta-\alpha) - 2a\cos\alpha\sin(\beta-\alpha) = 0$$

Hence either $\beta = \alpha$ or $a = e^{\pm j\alpha}$. The complex solutions are not admissible, especially since real variables were assumed in differentiation. The only solution consistent with real finite values of the components of the networks is then $\beta = \alpha$. Equations (8) to (11) now show redundancy, and may be reduced to:

$$\alpha = \beta = \cos^{-1}\frac{a+b}{ab+1}, \quad b(b^2-1)\,R_0 = a(a^2-1)\,R_3$$

and for $$ab(a+b)^2 = (ab+1)^3 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (13)$$

In terms of R_3, the component values of the network of Fig. 1(a) are then:

$$R_0 = \frac{a(a^2-1)}{b(b^2-1)}R_3 \quad R_2 = \frac{ab+1}{b^2-1}R_3 \quad R_1 = \frac{a}{b}\,R_2$$

$$C_3 = \frac{1}{b\omega R_3}\sqrt{\left(\frac{b^2-1}{a^2-1}\right)} \quad C_2 = \frac{b^2}{ab-1}C_3 \quad C_1 = \frac{b^2}{a^2}C_3$$

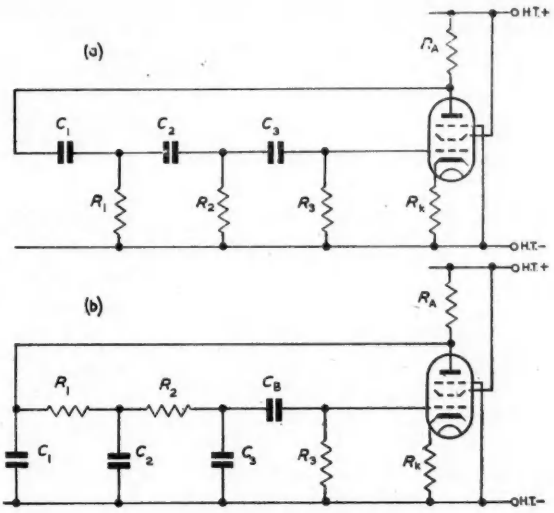


Fig. 2. Basic oscillator circuits

The component values of the network of Fig. 1(b) are:

$$R_0 = \frac{a(a^2-1)}{b(b^2-1)}R_3 \quad r_2 = \frac{a^2-1}{ab+1}R_3 \quad r_1 = \frac{a}{b}\,r_2$$

$$C_3 = \frac{a}{\omega R_3}\sqrt{\left(\frac{b^2-1}{a^2-1}\right)} \quad C_2 = \frac{ab-1}{a^2}C_3 \quad C_1 = \frac{b^2}{a^2}C_3$$

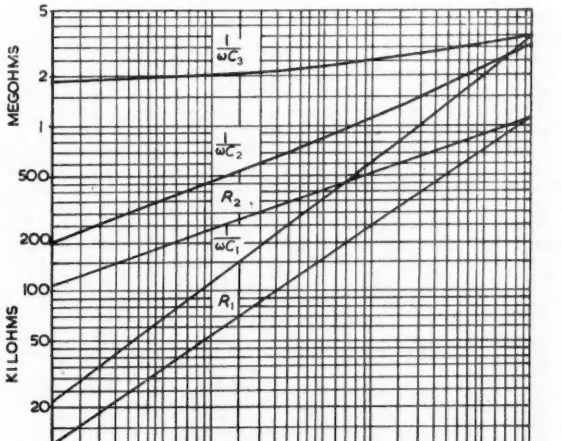
For both networks the attenuation factor, $-e_1/e_0$, is $\frac{2a^2b(a+b)}{b^2-1}$, from substitution in equation (7).

In all these expressions, a and b are related according to equation (13).

Application of the Results

Basic circuits involving the two networks are shown in Figs. 2(a) and 2(b). The use of pentodes is recommended since the frequency is more dependent upon the output impedance of the amplifying stage with this arrangement than with networks using conventional values. The

Fig. 3. Component values for the network of Fig. 1(a) for minimum attenuation with R_3 = 1MΩ



cathode decoupling capacitors which are usually shown in these circuits have been omitted. This is quite practicable because relatively little gain is required. While it is agreed that the negative feedback does not reduce distortion, it does reduce the variation of gain with ageing of the valve. It also reduces the dependence of output impedance on valve characteristics; and for low frequencies a bulky component is eliminated.

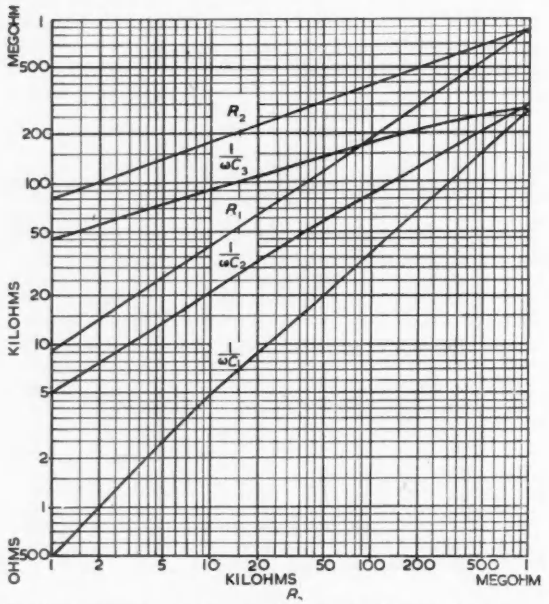


Fig. 4. Component values for the network of Fig. 1(b) for minimum attenuation with $R_3 = 1M\Omega$

Referring to Fig. 2(b), the blocking capacitor C_B should be located as shown, and not at the anode of the valve. The customary resistor between the anode and C_1 may be included if desired. This forms part of R_o, and increases the attenuation of the networks; for low frequencies it may save a bulky capacitor C_1.

At the risk of reviving old arguments, it is suggested that the first circuit is preferable for very low frequencies and the second for relatively high frequencies. The capacitors of Fig. 2(a) are of much smaller capacitance, while the valve capacitances of the second circuit are relatively unimportant.

Component values for minimum attenuation are plotted in Figs. 3 and 4. These curves are based on $R_3 = 1M\Omega$.

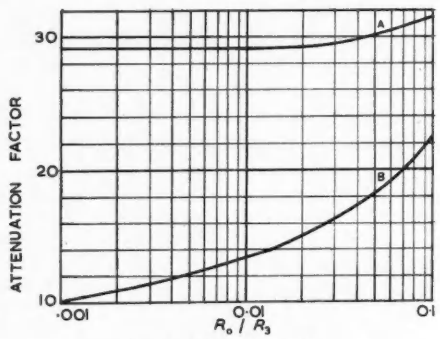


Fig. 5. Attenuation factor

Curve A. Network of Fig. 1(a) when $R_1 = R_2 = R_3$ and $C_1 = C_2 = C_3$.
Curve B. Either network of Fig. 1 with optimum component values.

For $R_3 = n$ MΩ, the figures of both scales should be multiplied by n. It was noted while compiling these curves that for all conditions $58{\cdot}7° < \alpha < 60°$. In Fig. 5, curve A is derived from the network of Fig. 1(a), and shows the attenuation which occurs when $R_1 = R_2 = R_3$ and $C_1 = C_2 = C_3$. Curve B shows the attenuation of either network when optimum values are used.

BIBLIOGRAPHY

1. BUTLER, F. Variable Frequency RC Oscillators. *Electronic Engng. 21*, 140 (1949).
2. DAVIDSON, J. A. B. Variable Frequency Resistance Capacity Oscillators. *Electronic Engng. 16*, 316 and 361 (1944).
3. GINZTON, E. L., HOLLINGSWORTH, L. M. Phase Shift Oscillators. *Proc. Inst. Radio Engrs. 29*, 43 (1941).
4. HINTON, W. R. The Design of RC Oscillator Phase Shifting Networks. *Electronic Engng. 22*, 13 (1950).
5. JOHNSON, R. W. Extending the Range of the Phase Shift Oscillator. *Proc. Inst. Radio Engrs. 33*, 597 (1945).
6. SULZER, P. G. The Tapered Phase Shift Oscillator. *Proc. Inst. Radio Engrs. 36*, 1302 (1948).
7. VAUGHAN, W. C. Phase Shift Oscillator. *Wireless Engr. 26*, 391 (1949).

COLOUR TELEVISION

At a recent demonstration by Marconi's Wireless Telegraph Co. Ltd, two systems of colour television adapted to present British standards were demonstrated. Both methods are fully electronic in operation and are compatible, though in varying degrees.

The first system is a straightforward adaptation of the American N.T.S.C. system, the complete signal being transmitted in the 3Mc/s bandwidth. In this system the full bandwidth of 3Mc/s is used to convey the luminance information, and the two colour difference signals are modulated on quadrature subcarriers of 2·6578125Mc/s within the luminance band. The existing BBC television signal waveform has not been altered except for the addition of the subcarrier and a sync burst of 9 cycles of subcarrier frequency at the back porch of the sync pulse, which is used to synchronize the colour detectors in this receiver; the peak white/sync ratio is reduced from 70/30 to 60/30 to partially accommodate the subcarrier overswing.

In the second system, known as the wideband system, the chrominance information is transmitted outside the 3Mc/s luminance channel; the chrominance signal occupying approximately 1·5Mc/s. Although this necessitates an increase of some 50 per cent in the total bandwidth required it results in better colour pictures and a very considerable improvement in compatibility. In the demonstration each of the three components was allocated a separate channel, i.e. a width 3Mc/s for the luminance information and 1Mc/s and 0·4Mc/s for the two colour difference signals, but in practice the two chrominance signals could be modulated on quadrature carriers or each have its own separate carrier.

Since the Television Advisory Committee has already proposed channel widths of 7·5Mc/s in Band IV and V the wideband system could be used without any difficulty, but in Bands I and III the necessary overlapping between adjacent channels would almost certainly produce objectionable crosstalk in fringe areas.

The experimental two-tube camera used takes advantage of the fact that human vision cannot discriminate colour in fine detail; an assumption common to both the systems of transmission described. One camera tube produces a high definition monochrome signal of 3Mc/s bandwidth and the other tube is arranged to give two low definition colour signals by means of a colour filter of alternate red and blue strips at right angles to the scanning lines. This type of camera has economic advantages over the more normal three-tube types, which in any case produce more colour information than is required by the transmitting system. It also has a number of technical advantages over the current type of single tube camera in which a very fine colour grid of red, green and blue strips is used. With this system the colour grid must have a resolving power of two to three times that of the equivalent monochrome picture; a requirement which is contrary to the principle, employed in the transmitting systems, of restricting the definition of the colour information.

The pictures were presented on both RCA tri-colour tubes and on a modified triple-tube Philips-Schmidt projector unit.

Short News Items

The Radio Industry Council announces that Sir Miles Thomas, chairman of the British Overseas Airways Corporation, is to open the National Radio Show at Earls Court, London, on 25 August. The exhibition remains open until 4 September and there will be a preview for overseas visitors and other social guests on 24 August. Mr. Clive Rawes has been appointed as programme officer for the Radio Show and Mr. A. E. Lloyd Williams as stage manager/producer, both being seconded by the BBC for the period of their special duties.

The City and Guilds of London Institute, Department of Technology, has prepared a five-year part-time course in Instrument Making which will come into operation for the College session 1954/55. This course has been arranged in response to requests from a number of member organizations of the Scientific Instrument Manufacturers' Association of Great Britain Ltd. Particulars of the course are given in a pamphlet, price 6d., which may be obtained from the City and Guilds of London Institute, Department of Technology, 31 Brechin Place, South Kensington, London, S.W.7.

The Department of Scientific and Industrial Research announce that the Lord President of the Council has appointed Sir Hugh Beaver to be Chairman of the Advisory Council for Scientific and Industrial Research in succession to Professor Sir Ian Heilbron, who retires on 30 September on completion of his term of office. The Advisory Council for Scientific and Industrial Research is composed of persons eminent in industry and science. Its task is to advise the Lord President of the Council on the policy and activities of the Department of Scientific and Industrial Research.

Marconi's Wireless Telegraph Company Ltd, and International Aeradio Ltd have together secured a substantial contract for radio communication and direction-finding equipment from the Ministry of Defence of the Republic of Syria. This contract entails the planning and engineering of a complete radio communications network, which is to include automatic and manual V.H.F. direction-finding stations (both mobile and static), with associated V.H.F. ground-air communications facilities. A training school for personnel of the Syrian Air Force is also to be provided, the two companies being responsible for every phase of this.

Cinema-Television, the Rank Organization associate company, announce that a Cintel large screen television was recently installed in the Palais de Chaillot, Paris, by the Compagnie Francaise Thomson-Houston, for the first large screen television demonstration in France. The Thomson-Houston Company in France believe that there is a big future for large screen television there and will fulfil initial orders by buying large screen projectors from Cinema-Television Ltd.

The Technical College, Bradford, Department of Electrical Engineering, announce that a course of eight lectures on The Principles and Applications of Transistors will be given by Dr. G. N. Patchett, the head of the department. The lectures will be held on Wednesdays at 7 p.m. commencing on Wednesday, 29 September. The fee for the course will be £1 10s., and students should possess a degree, a higher National Certificate in Electrical Engineering, or other suitable qualification. Application forms may be obtained from the Principal, Technical College, Bradford, 7.

British Insulated Callender's Cables Ltd announce that Mr. W. H. McFadzean has become chairman of the company on the retirement of Sir Alexander Roger.

The Royal Society, under the terms of the scheme to commemorate the late Lord Rutherford of Nelson, announce the appointment of Dr. E. Marsden of New Zealand, as the Rutherford Memorial Lecturer for 1954 and Mr. D. M. Brink, a graduate of the University of Tasmania, as a Rutherford Scholar for three years to carry out research in nuclear physics at the Clarendon Laboratory, Oxford.

Aluminium Laboratories Ltd, the research, engineering and geological exploration unit of Aluminium Ltd, have announced the completion of the new extensions to their research laboratories at Banbury, Oxon. The buildings were designed by Sir Percy Thomas & Son of Cardiff and incorporate many of the latest developments in laboratory design.

The BBC is putting in hand arrangements for the provision of a television service to the Channel Islands. A receiving station will be set up at Torteval on the south-west coast of Guernsey. This station will use high gain directive receiving aerials for the reception of the high power television transmitting station at Wenvoe, near Cardiff. An alternative aerial system directed on to the Alexandra Palace television transmitter will also be erected at Torteval. By arrangement with the General Post Office the received picture will then be transmitted by radio link to Les Platons on the north coast of Jersey. At Les Platons a television transmitter operating on a 61·75Mc/s vision and 58·25Mc/s sound with a power of ¼kW, will give a service to Jersey, Guernsey and Sark. It is expected that Alderney will also receive a service.

Land, Speight & Company Ltd, of Glasgow, announce the formation of a new company, Elesco Electronics Ltd, to act as the selling organization for the electronic and electrical equipment which they handle.

Group Captain P. Allerston, recently retired from the R.A.F., has been appointed manager of the Equipment Servicing Department of A. C. Cossor Ltd. He will be responsible for the installation and maintenance, both at home and overseas, of the firm's large and small airfield control radar, their Gee ground and airborne equipment and other equipment in the radio and radar fields.

Commander C. M. Jacob, R.N. (Retd.), has been appointed deputy technical manager of the Marconi International Marine Company Ltd.

Mr. A. E. Grimsdale, Special Assistant Sales Management, Metropolitan-Vickers Electrical Co., Ltd., has been appointed a Director of Metropolitan-Vickers Electrical Export Co., Ltd.

Mr. A. Simpson of The General Electric Company was awarded an M.B.E. in the Birthday Honours List. Mr. Simpson has been engaged in the design of radio equipment in the Coventry group of the General Electric Company for the past 19 years. After a short time in the domestic receiver field, he transferred to the Communications Group to complete the development of the receiving station used by the South African Broadcasting Company to relay the BBC programmes. Subsequently, he was a member of the small team which made the initial investigation into V.H.F. radio. This led to the airborne radio telephone and police radio as it is known today. During this period, he developed the first V.H.F. superhet receiver ever to be manufactured commercially. Mr. Simpson has also contributed articles to ELECTRONIC ENGINEERING.

Errata. It is regretted that in the June issue the degrees and qualifications of Mr. W. Morcom of Marconi's Wireless Telegraph Co. Ltd, were omitted from the heading of his article, "A High Power Communication Transmitter," which appeared on page 237. These should read, "W. Morcom, B.Sc.(Eng.), A.C.G.I., Wh.Sch., M.I.E.E."

LETTERS TO THE EDITOR

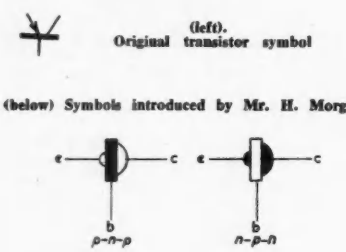
(We do not hold ourselves responsible for the opinions of our correspondents)

Theoretical Transistor Symbol

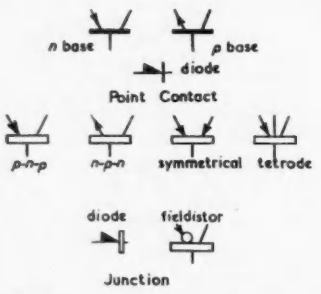
DEAR SIR,—There has been some correspondence regarding the theoretical symbol to be employed for transistors in both *Electronic Engineering* and *Wireless World*.

Mr. L. Molyneux in the April issue suggests a rather curious symbol resembling a bucket and spade on the grounds that, as the collector is shown detached from the base, one can more easily visualize the existence of collector-base potential, the emitter being shown by the usual arrow. This appears illogical to say the least as the basic dissimilarity between the transistor and the thermionic valve is that the transistor is a current operated device with all its elements in physical contact.

It is not stated whether this symbol is intended to be applied to both point contact and junction transistors. It appears, however, to break down when applied to symmetrical junctions.



A suggestion was also made by Mr. F. Oakes that the original symbol for the transistor introduced by Shockley was adequate. This, however, was refuted by Mr. H. Morgan who, while considering this symbol adequate for point contact transistors introduced symbols for junctions discriminating emitter and collector on the basis of differently sized segments attached to a rectangular base, p and n germanium being discriminated by shading (*Wireless World*, March and April, 1954).



Suggested symbols for current types of transistors.

This is a reasonable suggestion but hardly fulfils its claim to simplify drawing office work.

I would suggest that the present symbol is adequate and, if distinction between junction and point contact transistors is required, the junction may have the base shown as a box, the direction of the arrow on the emitter indicating the direction of flow of holes in the conducting direction (conventional direction of current flow).

These symbols appear to cover most present day types of transistors, though it appears difficult to fit any symbols to such devices as analogue transistors.

Yours faithfully,

D. NAPPIN,
South Harrow.

The correspondent replies:

DEAR SIR,—Mr. Nappin has been much kinder in his description of my transistor symbol than have some friends from the Department of Psychological Medicine. However, to answer his more serious points—when the transistor is being used as an amplifier of small signals, then the concept of the interconnexion of its electrodes is, of course, sound, and since mathematical relationships and design procedures have been developed it is quite possible to predict its behaviour at any time during the cycle. When transistors are used in switching circuits, where the linear relationships no longer hold, it is necessary to follow in the imagination, or on paper, the behaviour of all electrodes at all times, and in doing this, one inevitably gives some form to a phenomenon which, of itself, has none.

In the literature mechanical movement is frequently implied, and most teachers invent some form of model. At least one eminent professor is known to think in terms of buckets of water fitted with interesting taps. When a form of apparatus is invented, it is represented in a symbolic way which usually follows closely the mechanical form of the original. The symbol for the thermionic valve is almost a plan view of its physical arrangement, and the fact that it has remained almost unchanged since its introduction is perhaps a measure of its emotive power.

A major change, suggested some years ago[1], was founded on draughting convenience, though this approach has never been considered for other branches of engineering drawing. It is, perhaps, unfortunate that the mechanical arrangement of a transistor, on which the generally accepted symbol appears to be founded, does not lend itself readily to acceptable imagery. This has worried one leading authority[2] to the extent of causing him to invent and use throughout a paper, a new symbol which possesses desirable emotive qualities.

Yours faithfully,

L. MOLYNEUX,
Newcastle-upon-Tyne.

REFERENCES

1. KEEN, A. W. *Wireless World 73*, 99 (1947).
2. WILLIAMS, F. C. and CHAPLIN, G. B. B. *Proc. I.E.E. 100*. Part 3 (1953).

Microphony in Voltage Reference Tubes

DEAR SIR,—I should like to comment on the letter by Messrs. Aitchison and Murray in the May, 1954, issue regarding a comparison of the microphonic properties of the reference tubes types 85A1 and QS83/3, when subjected to mechanical shock. It would seem that the 85A1 is being used under conditions for which it was not designed and for which another tube, the 85A2, is more suited.

The 85A1 was designed a number of years ago at a time when the requirement was for a tube which would give extremely good reference voltage performance, both long and short term. The performance of the tube under mechanical shock was considered of minor importance compared with its normal electrical behaviour. For this reason a valve was produced which had no mica supports or spacers present in its structure, since gas liberated from mica is one of the major causes of instability in glow discharge tubes. It was stated in the published data for the 85A1 that the tube should not be subjected to shock or vibration.

Against this background the results quoted for the microphonic output of the 85A1 are not surprising. It should be remembered, however, that very few applications can tolerate absence from microphony if the price to be paid is poor burning voltage stability, either during operation or on shelf. The complete performance of the tube should therefore be considered when comparisons are made.

As the application of reference tubes was extended, particularly for military and industrial equipments, a more rugged tube was required to replace the 85A1; the 85A2 was developed to meet these needs. The 85A2 also dispenses with mica but has multi-supported electrodes which give greatly increased rigidity. This design has led to a tube with a stability equal to that of the 85A1 and a microphony performance which is of the same order as that of the mica supported valve quoted by your correspondent. In addition, a special quality version of the 85A2 has been developed under Government contract to meet the stringent specification laid down by the British Services for reliable valves. I therefore feel that

comparison of the microphonic properties of reference tubes should be related to this type of valve.

Yours faithfully,

K. F. GIMSON,
Industrial Technical Service Department,
Mullard Ltd.

High Speed Magnetic Amplifiers

DEAR SIR,—Mr. A. E. Maine, in the May issue, gave a very clear picture of recent developments in quick response magnetic amplifiers. We wish to add some notes on our own experiences with some of these devices.

As the author has pointed out, the quick response of the amplifiers is obtained at the expense of power gain. The smallness of this gain usually makes it desirable to approach the maximum theoretically possible power gain for a certain time-constant, as closely as possible. This can be done by careful attention to the circuit design, etc. Three points are particularly important. Firstly, maximum gain condition exists when the load resistance is equal to the internal impedance of the amplifier, as one would expect. Secondly, the power which a reactor is required to dissipate can be limited without reducing the power gain. For instance, if in the Lufcy bridge amplifier, Fig. 6(d), a resistor is included in series with the power supply, the output current can be limited to suit the maximum dissipation of the reactors. The inclusion of this resistor does not affect the current gain because the average output current is proportional to the difference in flux change in the two cores and independent of the supply voltage. This also eliminates the two unfavourable features of the circuit, pointed out by the author for D.C. output. Thirdly, a high permeability core material requires better rectifier performance than that given by the selenium type.

A feature of magnetic amplifiers which is not usually fully realized is the limitation the rectifiers have had on their performance in the past. For instance, the design criteria laid down by Milnes[1] using selenium rectifiers limits the current turn gain of a single half wave unit to about 100, whereas an ideal rectifier could give a current turn gain of the order of 800. In the case of Ramey circuits, the limitation is even more evident due to the form factor of the input current. The introduction of the germanium junction rectifier into this field will greatly improve magnetic amplifier performance in general and make the quick response amplifier a much more promising proposition.

We feel that the half wave circuit of Lufcy has a much more promising field of application than the author has indicated. Except for full wave output applications this circuit can give a performance comparable with any other magnetic amplifier, with fewer components. The phase/frequency response characteristic can be varied from a limit set by the supply frequency by inserting an impedance in series with the input. This also varies the current gain by controlling the circulating current in the input circuit. When a single cycle response is desired together with maximum power gain a resistance equal to the input reactance is included. Under these conditions the current gain of the Lufcy circuit is about one quarter to one eighth of that obtained from the Ramey type of switched input circuit due to the circulating currents in the former and the input current form factor of the latter. However, when used in interstage amplifiers, the input of the Lufcy circuit is automatically switched by the preceding stage and the amplifier has a gain of similar order to the Ramey circuits.

In the case of the input stage, we doubt whether the switched input circuits are warranted since they increase the sensitivity only at the expense of simplicity and possible drift stability.

One point worth mentioning in connexion with these amplifiers is that the core characteristics of certain materials under certain operating conditions can produce instability. It is found that symmetrical dynamic *BH* loops, for Permalloy-F cores cannot be observed when sinusoidal flux changes of amplitude less than the saturation value are applied. The loop is triggered into one of its two possible saturated loops depending on the initial conditions. In the Lufcy amplifier with a resistor R_P in series with the power supply to limit the current, instability may occur when R_P is greater than the load resistor R_L. For certain initial conditions the amplifier behaves normally until the input current rises above a specific value. When this point is reached it is impossible to put it back into its original state by varying the input current. The amplifier will now produce its maximum output current in either the positive or negative direction depending on the polarity of the input current. The amplifier can be returned to its original condition by momentarily short-circuiting R_p. In the normal condition both cores are able to saturate during the supply cycle. In the abnormal case the core which the input current drives away from saturation cannot reach saturation. This is due to the small voltage drop across R_L when the other core has fired. Thus as long as both cores saturate no instability will occur. However, when one core remains unsaturated for the whole supply cycle instability is produced by the core characteristics. In order to avoid this effect it is necessary to arrange the operating conditions so that both cores will always saturate over a complete range of firing angles. This can be arranged by supplying the cores during the non-conducting half cycle with a saturating pulse before they are reset.

Yours fathfully,

D. F. WALKER and E. T. ANGUS,
Applications Laboratory,
Ferranti Ltd.

REFERENCE

1. MILNES, A. G. Letters to the Editor. *Electronic Engineering 25*, 443, (1953).

The Author replies:

DEAR SIR,—The letter of Messrs. Walker and Angus will be of interest to those concerned with the development of high speed circuits since it underlines important factors of design and also focuses attention on instability effects experienced with Permalloy-F. In this latter connexion we first observed the effect when attempting to display symmetrical hysteresis loops on a C.R.T. visual display unit. It was found that the loop remained at either the upper or lower saturation level, and could be moved from one datum to the other by means of introducing a switching transient into the system. The actual transition was readily observable and occupied a large number of cycles of the excitation supply. The mechanism involved is complicated and results in the starting point of successive loop cycles being displaced progressively in a general upward and downward direction. The effect, which applies to practically all square loop materials has been described by Batdorf and Johnson[1] and the conclusions show that the phenomenon is a property of the material itself. The counter-measures described by Walker and Angus represent a successful circuit technique but one is bound to feel that the elimination of the effect itself is what is really needed.

It is regretted if my recent article suggests that the Lufcy amplifier is unduly limited in application and the writer certainly agrees that this amplifier offers a very high performance for only a small outlay of components. In contrast to schemes laid down in Lufcy's original paper it has been found that the best performance is obtained when using several stages in cascade, all operating with late quiescent firing angles (150° or more). A 4-stage arrangement of this sort can furnish power gains of 10^6 with a response time of only 2 cycles of the supply frequency. In spite of this, the writer still feels that there are many instances where other forms of amplifier suit a given problem rather better, and the original statement should be interpreted in this context.

The importance of the series resistance in the Lufcy bridge amplifier has been stressed, but the writer feels that a more vital function that this performs concerns "firing angle expansion" through a multi-stage arrangement. Without the resistance, a control signal of sufficient amplitude to unblock the main rectifiers would be short-circuited resulting in only a limited flux re-set. With the resistance in circuit, however, the excess voltage may be absorbed, thus permitting the full flux change to be impressed in the core.

The writer hesitates to generalize on the question of switched or non-switched control circuits, since the choice of these is apt to be determined by the particular functions required of the amplifier. It is, however, interesting to note that a recent paper[2] describes Ramey type amplifiers which have no rectifiers in the control circuits and are free from the limitation of current gain, turns ratio, and source impedance which apply to Lufcy and similar couplings.

Yours faithfully,

A. E. MAINE.
De Havilland Propellers Ltd.

REFERENCES

1. BATDORF, S. B., JOHNSON, W. N. Instability of Self-Saturated Magnetic Amplifiers Using Rectangular Loop Core Materials. *Trans. Amer. Inst. Elect. Engrs. 72*, Pt. I, 223, (1953).
2. SCORGIE, – Fast Response with Magnetic Amplifiers. *Trans. Amer. Inst. Elect. Engrs. 72*, Pt. I, 741, (1954).

ELECTRONIC EQUIPMENT

A description, compiled from information supplied by the manufacturers, of new components, accessories and test instruments.

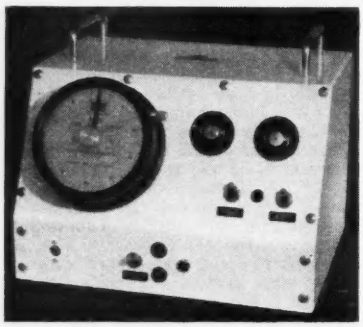
Electronic Counter

(Illustrated below)

THIS is mains operated resettable equipment and is capable of counting electrical pulses up to a rate of 5 000 per second (300 000 per min.).

The unit consists of two Dekatron counter tubes feeding a high speed electro-mechanical register, complete with the necessary power supplies and driver stages, all mounted in one cabinet. Counter tubes indicate "Units" and "Tens" and the High Speed Register indicates "Hundreds" up to a maximum count of one hundred million pulses.

A front panel switch starts and stops the count and a spring loaded switch resets the Dekatron tubes. The High Speed Register is reset by means of



knurled knobs. Indicator lights are provided for "Mains on" and "Count" and the protective fuses are accessible from the front panel. The input socket accepts standard ¼in coaxial cable which may be of any reasonable length.

Pulse input is 10 volts peak, positive or negative, although this can be varied within fairly wide limits to suit individual requirements.

A range of pick-ups suitable for use with this equipment is also available.

Davis, Wynn & Andrews, Ltd,
Vittoria House,
Cheltenham.

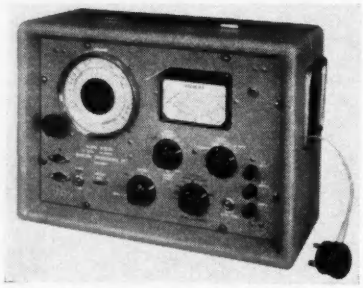
Audio Tester

(Illustrated above right)

THE audio tester TF 894A comprises a portable beat-frequency oscillator and output meter. The oscillator is directly calibrated from 50c/s to 27kc/s in two ranges, has a maximum power output of 2 watts into 600, 15, or 3ohm.

The instrument includes an output meter and constant-resistance 600Ω step attenuator, both of which carry power and voltage calibrations providing an overall output range greater than 60db.

For operation at the alternative impedances of 15Ω and 3Ω the attenuator is switched out of circuit, the output level then being read on the voltage scale of the output meter and adjusted by means of the level control.



Provision is made for the injection of a voltage at the supply frequency when standardizing the frequency scale and, as an added facility, the output meter may be switched to measure external audio frequency voltages in three ranges up to 80 volts, so that the instrument may operate as a self-contained unit for the testing of audio amplifiers.

Marconi Instruments Ltd,
St. Albans,
Hertfordshire.

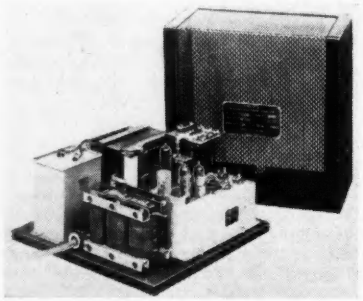
Voltage Stabilizer

(Illustrated below)

THE voltage stabilizer type S53150 is of the saturated transformer type but in addition has an electronic circuit to guard against output voltage variation due to changes in the supply frequency. The output from the saturated transformer is fed to a voltage sensitive detector producing an out-of-balance signal if the output of the stabilizer departs from its correct R.M.S. value (due, for example, to a change of frequency or load power factor). The signal is amplified and fed to the control winding of a saturable reactor. The phasing is such that the effect of the reactor on the saturated transformer is to restore the output voltage to its correct value.

Input voltage may vary between 180-250V and frequency from 47-51·5c/s. The unit has a rating of 150VA and is unaffected by load variations in this range.

Philips Electrical Ltd,
Century House,
Shaftesbury Avenue,
London, W.C.2.



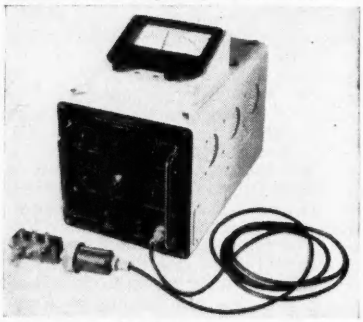
Electro-manometer

(Illustrated below)

THE N.E.P. electro-manometer is intended primarily for the measurement of intracardiac and intravascular pressures but it is equally useful for industrial pressure analysis and a range of pressure heads for this purpose is in hand.

The standard pressure head is of the capacitance type, of low volume displacement and inherent high frequency response. It is temperature compensated and linear within 2 per cent over each of the five ranges up to 400mm Hg pressure or vacuum. Cable lengths up to 10ft do not affect the sensivity.

The detector-amplifier contains a stable radio-frequency oscillator, fre-



quency-modulated by the pressure head. The change of frequency is proportional to pressure, and is converted to an output voltage and current, sufficient to operate the large meter incorporated and also an external mirror-galvanometer, oscilloscope and recorder-amplifier. The power supplies are electronically stabilized and operation is unaffected by X-ray equipment.

New Electronic Products Ltd,
9 New Cavendish Street,
London, W.1.

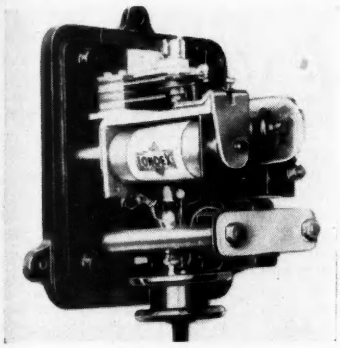
Electronic Relay

(Illustrated above right)

THE electronic relay Type CCR is housed in a dust-proof cast aluminium casing. It consists essentially of a small transformer for isolating from the mains, one gas-filled relay and a Type KR relay fitted with single pole change-over output contacts, switching capacity up to 2A at 250V A.C.

When the "trigger" circuit is completed, the cold-cathode valve strikes, energizing the KR relay which is connected in its anode circuit. When the "trigger" circuit is broken the valve extinguishes, de-energizing the relay.

The sensitivity is such that the cold-cathode valve will strike even if the "trigger" circuit is completed through an external resistance up to 2MΩ. The current in this circuit is then only approximately 0·03mA. The circuit is so designed that even when the "trigger"



circuit is completely shorted, the maximum current that can flow is only approximately 0·1mA; so that it can be switched by the most delicate contacts without damage due to arcing or burning.

Londex Ltd,
Anerley Works,
207 Anerley Road,
London, S.E.20.

L.R.F. Amplifier

THE Savage L.R.F. amplifier is designed for use with magneto-striction, moving-coil or moving-iron transducers and will find a ready application where high frequency vibration testing or research is to be done. The amplifier has a maximum output of 1kW and there are two models which cover respectively the frequency ranges 1·5kc/s to 30kc/s and 5kc/s to 100kc/s. The output transformer is tapped to provide output voltages of 25, 50, 75 and 100 and full output is obtained for an input of 0·5V at 600Ω.

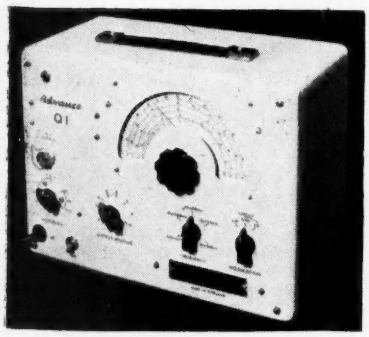
The frequency response of the amplifiers is flat within their respective bands and the application of negative feedback ensures a good waveform at the output terminals. The amplifier is carried on a 6ft 6in rack 21in wide and 14in deep. It is powered by 50c/s supply mains (single phase) and transformer taps mains voltages from 200-250.

W. Bryan Savage Ltd,
Westmorland Road,
London, N.W.9.

V.H.F. Signal Generator

(Illustrated below)

THE Advance type Q.1 signal generator has been produced primarily to meet the needs of servicemen dealing with band 3 television.



It provides signals from 1μV to 100mV into 75Ω over a frequency range of 7·5Mc/s to 250Mc/s. The instrument contains a variable capacitance tuned Colpitts oscillator with switched inductors for five ranges. The frequency is directly calibrated, the calibration being displayed on a large scale of total scale length—37½in. The oscillator may be internally anode modulated to give 30 per cent sine wave modulation at 1 000 c/s, or it may be internally grid pulsed giving 50/50 square pulses at a repetition rate of 1 000 per second.

A termination unit is provided to correctly terminate the R.F. output lead.

Advance Components Ltd,
Back Road, Shernhall Street,
London, E.17.

Miniature C.R.T.

(Illustrated above)

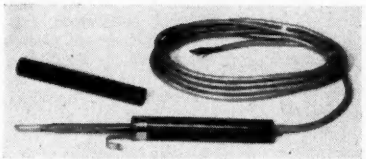
THE ICPI is a small cathode-ray tube intended for incorporation into electronic equipment for monitoring purposes. The screen diameter is approximately 1in, and the overall length 4in. It has electrostatic deflexion and fixed electrostatic focus. A voltage of between 500 to 800V is required for anode 3. The sensitivity of the X plates is $90/V_{a3}$mm/V and of the Y plates $110/V_{a3}$mm/V.

Electronic Tubes Ltd,
Kingsmead Works,
High Wycombe,
Buckinghamshire.

Soldering Irons

(Illustrated below)

THE Litesold soldering irons are available in a range of sizes having bit diameters between ⅛ and ¼in. The smallest of these is 6in long and weighs only ½oz without flex; a cover is provided to protect the bit when not in use, and for when it is desired to pack



the iron while it is still hot. These irons are available for use on a number of voltages between 6V and 250V.

Light Soldering Developments Ltd,
30-32 Devonshire Road,
London, S.E.23.

Electroformed Waveguides

AN electroforming service is provided by the Middlesex Gun Co. This process facilitates the production of intricate internal forms which must be manufactured to close tolerances. By this method a degree of accuracy can be obtained which would be virtually impossible by fabrication. Electroforming, therefore, is particularly suited to the production of waveguides and microwave equipment, i.e., taper sections, stepped waveguides, and resonant cavities.

Copper is the metal most commonly deposited, but electroforms can be produced with an initial deposit of ·003/·005-in. silver or nickel, backed with copper to the required wall thickness.

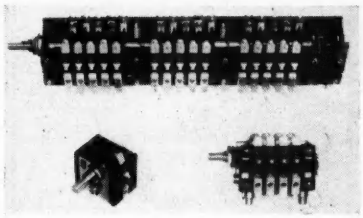
The metal is grown on mandrels of stainless steel, wax or other soluble plastic. When the specified thickness has been obtained, the mandrels are extracted, leaving a bore of the required shape and size, in fact, an exact internal reproduction of the mandrel.

The Middlesex Gun Co., Ltd,
Hall Con Mill,
Rawtenstall, Rossendale,
Lancashire.

Multi-Contact Switches

(Illustrated below)

THESE Magnum switches are of the cam and roller type, the contacts being operated by a series of insulated cams which impart a wiping movement to the contacts while pressure is being applied. The cams can be arranged to operate the contacts in an almost unlimited number of combinations. They are available with contacts rated at 5, 10 and 15A. These switches can



be supplied in contact combinations to suit requirements.

Burne-Jones & Co., Ltd,
309-317 Borough High Street,
London, S.E.1.

Miniature Power Relay

THE new type M power relay incorporates two micro-switches providing two changeover combinations capable of switching 5A at 230V A.C. Each microswitch is enclosed in a separate moulded case. The power consumption of the coil is 0·85W at from 6 to 120V D.C. The operating time at nominal applied voltage is 25 to 40msec. The mounting and terminal arrangement can be varied to suit customers requirements. The overall dimensions of this relay are 1¼in × 1 9/16in × 1⅝in.

P.A.R. Ltd.,
95 Talbot Street,
Nottingham.

Heavy Duty Switch

A NEW switch, the Tenamp, has recently been introduced by Austinlite Ltd. It has a two pole four way slow make and break action. Contact pressure is provided by a compression spring which does not carry current. The A.C. rating is 5A at 440V and 10A at 250V and the D.C. rating 5A at 250V.

Austinlite Ltd,
Lighthouse Works,
Smethwick, Birmingham.

Lange, Maxwell & Springer Ltd.

New books of interest

FROM THE

PERGAMON PRESS

* *Editor for the Electronics and Waves series:* D. W. Fry (Harwell)

***Millimicrosecond Pulse Techniques**
I. A. D. LEWIS & F. H. WELLS
(Atomic Energy Research Establishment, Harwell)
312 pp. approx. 162 illus. 40s. net

*** Probability and Information Theory with Applications to Radar**
P. M. WOODWARD
(Telecommunications Research Establishment, Ministry of Supply, Malvern)
128 pp. 20 illus. 21s. net

***Signal, Noise and Resolution in Nuclear Counter Amplifiers**
A. B. GILLISPIE
(Atomic Energy Research Establishment, Harwell)
154 pp. 61 illus. 21s. net

***Scintillation Counters**
J. B. BIRKS
(Rhodes University, S. Africa)
148 pp. 63 illus. 21s. net

***Physics and Applications of Secondary Electron Emission**
DR. H. BRUINING
(Philips Research Laboratories Eindhoven, The Netherlands)
178 pp. 134 illus. 25s. net

Soft Magnetic Materials for Telecommunications
Edited by
C. E. RICHARDS & A. C. LYNCH
346 pp. 181 illus. 63s. net

LEAFLETS ON REQUEST

242 Marylebone Road, London, N.W.1
Ambassador 3421

BOOK REVIEWS

Principles of Transistor Circuits

Edited by Richard F. Shea. 535 pp. 469 figs. Demy 8vo. Chapman & Hall Ltd. 1953. Price 88s.

THE experienced designer of electronic circuits using conventional valves often under-estimates the part played by his own experience in determining his approach to everyday circuit problems.

He will automatically reject circuits depending for their action on those valve parameters which have a wide spread of characteristics (e.g. grid current), even though he may not consciously consider what is happening. Indeed, an approach to the more normal routine of circuit design can become a habit, and if the habit is a good one this need not be a serious disadvantage.

When, however, such a person turns to newer devices, and in particular to the transistor, such habits, acquired unconsciously for use with valves, can become very dangerous.

So far any attempt on the part of the enlightened circuit designer to acquire a new set of techniques for use with transistors has always been difficult. The information has been comparatively scarce and what is available spreads over a wide range of journals and technical publications.

It is with the understanding that the transistor is a quite separate and different device from the radio valve, that the reader should approach the present book. In its 530 pages it covers the beginnings of the new science of transistor circuit design. Starting with a short chapter on semi-conductor physics, it then goes on to introduce both the germanium point-contact and junction triode. Subsequent chapters consider low frequency amplification; methods of stabilizing the D.C. working point of transistors; power amplifiers; direct current amplifiers; narrow-band, tuned amplifiers for radio and intermediate frequencies; wide-band and video amplifiers; oscillators; and finally non-linear large amplitude circuits such as time base saw tooth oscillators, multivibrators and scaling circuits.

Additional chapters deal with matrix methods of circuit analysis, transient phenomena and noise. A large and comprehensive bibliography together with a list of symbols and technical terms completes the book.

While this first published full length work on transistor circuits should find a place on every circuit designer's book shelf, it has three serious limitations.

The first, which of course cannot be overcome, is that the science of transistors is developing so rapidly that even those actively engaged in their manufacture are finding it needs considerable effort to keep up with their own advances. The reader of this book should therefore regard it as a background to the art rather than an exposition of the latest developments.

The second limitation lies in that the American approach to circuitry appears to differ fundamentally from the British. Even as early as page 33 out of over 500 pages, the reader is introduced to the equivalent circuit; from then on the major emphasis is on the "Black Box" rather than on the transistor physics itself. The so-called duality between transistors and valves is emphasized, as are also matrix algebra methods of solution to the equivalent network.

In the reviewer's opinion, equivalent circuits should only be used after the circuit designer has a clear picture of the physical principles in operation in the transistor itself. Answers obtained from the "Black Box" are only as good as the original data fed into it. Only after the designer understands the physical picture and can decide for himself if his particular problem and frequency of operation come within the scope of the transistor parameters and particularly equivalent circuit, should he use this potentially dangerous short cut.

As for "duality," the ability to take portions from the prior art of valve circuits and transform them into transistor equivalents is very useful for the experienced designer, but such possibilities should not be used as an excuse for failing to understand transistors from the basic approach.

Here again, due to the different spreads of characteristics in manufacture, limitations of transistor physics, and the varying circuit requirements between transistors and valves, they are not always duals of each other.

Duality and equivalent circuits might have been better covered at the end of the book rather than near the beginning. Both principles are quite useful servants, but used without discretion very bad masters.

As to the third limitation, while the transistor symbols used in this book are clear and easy to understand, particularly since the actual transistor itself is drawn in a circle, the circuit arrangement is very poor. In many cases, the H.T. positive and negative lines are both drawn at the bottom of the circuit and it is not immediately apparent from which line the supply for a particular collector or emitter is coming.

This arrangement was used when drawing valve circuits in about 1930 but it has since been almost entirely given up in favour of a logical system with the most positive H.T. at the top of the circuit and negative lines at the bottom. In valve circuits, the earth line was usually drawn about three quarters of the way down with negative supplies below it.

There seems to be no reason why this system should not be continued for transistors. For P.N.P. types, the top rail would be earthed and the bottom one merely labelled so many volts negative. Such a system would also logically accept circuits using both P.N.P. and N.P.N. transistors. In this book the system

used, where the lower rail is always earthed, will have no logical arrangement at all when both types of transistor are used together.

It is a great help when studying new circuits if the reader is always able to deduce the direction of current flow from the circuit layout.

However, in spite of these criticisms the book is an important contribution to the understanding of transistor circuitry and is well worth attention.

G. GRIMSDELL

Statistical Methods in Electrical Engineering

By D. A. Bell. 176 pp., 35 figs. Demy 8vo. Chapman and Hall Ltd. 1953. Price 25s.

DR. Bell is to be congratulated on producing an interesting book on statistical methods, for students and professional engineers. Reviews of books on statistics normally commence with a scathing account of the author's views on the foundations of the subject, but that is hardly fair in this case. The first chapter is a clear and very concise exposition of the various theories of probability and the rest of the book is written in the same way.

The author utilizes the mathematical equipment of the electrical engineer to concentrate on methods and principles. The concepts and methods are introduced one by one and illustrated by one or two examples, so that the reader can grasp the essential difficulties without being swamped by details. At places where the reader may feel in need of more information there are references to suitable textbooks or original papers.

It is hardly necessary to state that Dr. Bell has drawn in his examples with a very wide network, but the scope of the book is considerable for its size, and it concludes with chapters on fluctuation phenomena—the best examples occur in electrical engineering—and the theory of the transmission of information.

G. J. KYNCH.

Industrial Electronic Engineering

By W. L. Davis and H. R. Weed. 514 pp., 109 figs. Demy 8vo. Sir Isaac Pitman & Sons, Ltd. 1953. Price 55s.

THIS book is more suitable for the advanced student and young development and design engineer, than the industrial user of electronics.

While not covering the whole field of industrial electronics, the text makes a good qualitative approach to rectifier, photoelectric apparatus, timers, motor control, and R.F. heating.

The descriptive work with regard to valves is quite wisely confined to consideration of those of the vapour discharge type, e.g. thyratrons and ignitrons, and a good account is given of the lesser known phenomena in these types of valves.

The chapters covering the theoretical treatment of servomechanisms and regulators will be thought lengthy by many readers, by comparison with the remainder of the book. However, there seems fair justification for detailed treatment of feedback systems since the future of electronic control in industry is most probably tied up with feedback controllers of various kinds. Two minor defects have been noted in the chapter on servomechanisms; one page 328-9) which states that positive *CR* feedback is a satisfactory means of obtaining "proportional plus derivative" control. Few engineers with design experience in this field would agree with this statement. The other defect is mainly an omission and concerns the treatment of an *n* stage regulator, which is analysed, but no statement appears as to how it can be stabilized. The authors have missed a valuable opportunity of applying feedback theory in this more general case.

The cursory treatment of the saturable reactor will be considered misleading by those who have detailed experience with this type of device.

As indicated above the book is essentially a theoretical treatise and gives little application data, and no detail particulars of actual applications of electronic control to industry. However, as a book on quantitative treatment it can be recommended; the series of problems which terminate the major chapters are well chosen and will adequately test the abilities of the graduate student.

A. L. WHITELEY.

Microwave Spectroscopy

By M. W. P. Strandberg. 140 pp., 15 figs. Crown 8vo. Methuen & Co. Ltd. 1954. Price 9s. 6d.

THIS book is one in the series of Methuen's monographs on physical subjects which are intended to supply science students at university level with a compact statement of the modern position in each subject.

The text begins with a calculation of the quantum energy levels of a rotating molecule, and considers the various perturbations which may or must be recognized to interpret precise experimental data. The final sections deal with the instrumentation necessary to measure the frequencies in the microwave region which are characteristic of differences between these energy levels.

Static Electrification

104 pp. Crown 4vo. Supplement No. 2. The Institute of Physics. 1953. Price 25s.

IN the early part of 1951 a proposal was made to The Institute of Physics that a volume on the generation and effects of static electricity should be published in the Institute's series of Physics in Industry monographs.

It was eventually decided by the Board of the Institute that, in the present state of knowledge of the subject, it would be preferable to hold first a conference covering all aspects of static electrification and to publish the proceedings as a supplement to one of the Institute's scientific journals. The conference was held at Bedford College, London, on 25-27 March, 1953, and the papers presented, together with an edited account of the discussion, are contained in this supplement.

CHAPMAN & HALL

Just Published

APPLIED ELECTRONICS

by

Truman S. Gray

Assoc. Professor of Engineering Electronics Massachusetts Institute of Technology

Second Edition

881 pages 374 figures 72s. net.

ELECTRONICS

A Textbook for Students in Science and Engineering

by

T. B. Brown

Professor of Physics The George Washington University

545 pages 390 figures 60s. net

37 ESSEX STREET, LONDON, W.C.2

VOLTAGE STABILIZERS

By

F. A. Benson, M.Eng., A.M.I.E.E., M.I.R.E.

(University of Sheffield)

Price 12/6

(Postage 6d.)

This monograph describes the various devices employing saturated elements, glow-discharge tube circuits and thermionic valve arrangements for voltage stabilization. A comprehensive bibliography is included.

Order your copy through your bookseller or direct from

Electronic Engineering

28 ESSEX STREET, STRAND, W.C.2

BOOK REVIEWS (Continued)

Electrical Earthing and Accident Prevention

Edited by M. G. Say. 248 pp., 116 figs. Demy 8vo. George Newnes Ltd. 1954. Price 25s.

MOST electrical engineers, and still more electronic engineers, would probably consider that the subject of earthing for safety could be covered in one chapter of a book. This book shows how wide of the mark this is, and most engineers can read it with advantage. Being written by 19 contributors there is inevitable overlapping, but the obvious drawback of this is countered by the fact that for some specific points one reference is sufficient, provided that the reader has at least glanced through the book as a whole to know what is present.

The first chapter, on accidents and their prevention, is a fascinating one and worth study by all engineers. The subject of earthing, both single and multiple, and protection by voltage-operated and differential current earth-leakage circuit-breakers, and earth proving systems is well discussed here or in other chapters; the case for all-insulated domestic wiring systems is also well put by an authority on this subject.

In the chapters which may be considered as devoted to "power" those dealing with portable electrical appliances and machine tools will apply to all electronic engineers concerned with manufacture, but the chapters of more obvious electronic interest are those on the earthing of telecommunications systems, industrial electronic equipment, electromedical apparatus and radio frequency instruments.

The vast difference between an earth connexion suitable for D.C. and mains A.C. on the one hand, and a low-impedance connexion for a high frequency circuit is well brought out. As an example H.F. apparatus such as diathermy fed from A.C. mains is liable to feed a H.F. component back into the mains, causing interference, which is commonly filtered out by a system of $1\mu F$ from each line to earth. The preferred scheme is shown as $0{\cdot}1\mu F$ from each line to a common point, which is connected via $0{\cdot}01\mu F$ to earth.

The chapter on R.F. instruments is particularly interesting, and has applications to all electronic testing, including the mutual operation of a number of nearby instruments without interaction: screening as well as earthing is involved. Correct earthing for radio frequency measurements is an essential for accuracy of readings, rather than for shock prevention.

The hackneyed subject of earth resistance measurement and maintenance does not seem to admit of much new treatment, but in fact the subject is very well explained and much new material is given, including new nomograms to facilitate calculation of alternative earthing resistance arrangements.

The only point of criticism raised by the present reviewer is that the subject of earth electrodes is not well defined and stressed. Many chapters deal with the various methods, either one or all of them: buried plates, buried earth strips and driven rods and pipes. In some chapters the advantage of driven earth rods is stated, but in others only "earth plates" are mentioned. While this may be intended to cover all systems generally, as is in fact stated in one chapter, it is misleading since many readers will take it that "earth plates" means earth plates literally, whereas it has been published in various quarters over some years that the most efficient and economic method of reaching a given low resistance is by driven earth rods, with few exceptions such as in rocky ground. Code of Practice C.P. 326.101 on *Protection of Structures against Lightning* is mentioned in the book, but the preferred method of using any number of unit rods which can be screwed together is not quoted, although prominently recommended in the Code. Significant extracts from "Explanatory notes on some of the recommendations in the Code" include: "It will be observed that plate electrodes are not mentioned in the recommendations . . . ." "If the use of earth rods is impossible, the next best substitute is buried copper strip." A general reference to earth electrodes instead of earth plates, with details of earth rods, would be preferable to the present method of treatment in these chapters where such reference is made.

The book is well printed on good paper and the many line diagrams are very clear and explanatory. At 25s. the book is good value in these days.

E. H. W. BANNER.

Servo-Mechanisms

By J. C. West, 225 pp., 226 figs. Demy 8vo. Cleaver Hume Press Ltd. 1953. Price 25s.

THIS recent addition to servo literature deserves special consideration if only because it is a book of a new type. Intended for students whose first serious impact with the subject is at undergraduate level, it should particularly appeal to that majority of engineering students who remain unsatisfied with an abstract, theoretical approach to a subject and prefer a more practical treatment which introduces theory as and when required.

The "theme song" of the book, so to speak, is a simple low-power position control system, consisting in its original (and critically stable) state of two potentiometers and an idealized D.C. amplifier and field-fed servo-motor assumed free of time-lags. Variations on the theme occur in later chapters which embellish this electrical analogue of a simple pendulum by considering the effects on transient and steady-state sinusoidal response of friction, the motor field time-constant, velocity feed-back, and various other damping methods. Stripped of one integration the system becomes a velocity control. These "themic" chapters are interspersed with others of a more general theoretical character on such topics as stability, gain-phase criteria, static accuracy, etc.

In view of the wide field covered in a restricted compass, some of the chapters are rather sketchy, notably the one on non-linearities which should either be amplified or omitted in a later edition. Some aspects are entirely omitted; indeed the author concludes by a list of these to which it would be churlish to add. And if some passages are a little aggressively Mancunian who shall deny the author his parochial loyalties?

On the whole a very useful addition to undergraduate teaching of the subject, particularly if used in conjunction with a demonstration model as suggested by the author.

J. M. LAYTON.

Wireless and Electrical Trader Year Book 1954

296 pp. Demy 8vo. Trader Publishing Co., Ltd. Price 10s. 6d.

IN this edition, data of practical use to dealers and general reference and technical information have been carefully selected. A valuable new feature is the complete text of the wages agreement covering radio and television service engineers. The comprehensive list of the I.F. values of commercial radio receivers which have been marketed during the past six years has been revised and extended. Other data include specifications of current radio receivers, legal and licensing information and a directory of trade associations.

One of the principal aims of the Year Book is to assist traders to keep abreast of the constant changes in the names, addresses, telephone numbers and products of the firms engaged in the radio and electrical industries.

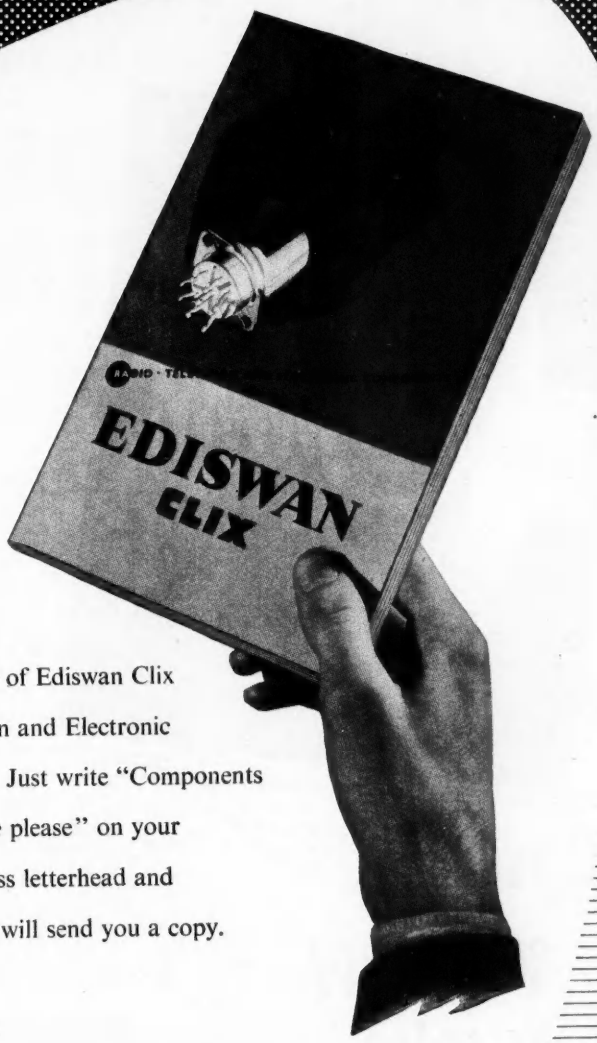
Optical Workshop Principles

By Charles Deve, translation by T. L. Tippell. 436 pp., 160 figs. Demy 8vo. 2nd Edition. Hilger & Watts Ltd. 1954. Price 42s.

THIS second English edition is a completely new translation of the French third edition of Colonel Deve's work, "Le Travail des Verres d'Optique."

The author was a pioneer in adducing theoretical bases for the manipulations required to produce optical work of high quality and in this book he very clearly set forth those principles. The work is very informative on workshop methods and recipes and gives useful data on abrasives and tools.

Chapters are devoted to the testing of raw material and work in progress; to cutting, grinding and polishing; to centring, edging and cementing; to engraving and to metallization. The production of aspherical surfaces is treated in some detail and work on glass and on crystals is described.



MANUFACTURERS OF EQUIPMENT, and DEVELOPMENT GROUPS are invited to send today for this NEW complete catalogue of Ediswan Clix Radio, Television and Electronic Components. Just write "Components Catalogue please" on your business letterhead and we will send you a copy.

EDISWAN
CLIX
RADIO COMPONENTS

THE EDISON SWAN ELECTRIC COMPANY LIMITED, *Member of the A.E.I. Group of Companies*
155 Charing Cross Road, London, W.C.2 and Branches. *Telephone: Gerrard 8660. Telegrams: Ediswan, Westcent, London.*
C.R.1a Radio Components Sales Office: 21 Bruton Street, London, W.1 *Telephone: Mayfair 5543*

this brochure will start you thinking

It describes robustly made switches — for duties ranging from light domestic to heavy industrial applications — they provide a new and simpler approach to switching problems : they save space, wiring, money . . . How and why you can see for yourself in "Simplified Switching".

you can get a copy by return of post from . . . . AUSTINLITE

AUSTINLITE LTD.,
LIGHTHOUSE WORKS,
SMETHWICK 40,
BIRMINGHAM.

Austinlite rotaries differ from other rotary switches in this : every switch is built for its job ; and Austinlite engineers take as much trouble to see that you get the right switch for the job—whether you want one, a hundred, or a thousand.

Air-damped

ANTI-VIBRATION MOUNTS

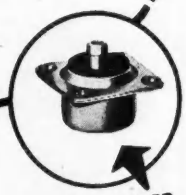
OF EXCEPTIONAL PERFORMANCE

for the protection of all types of airborne equipment . . .

Air-damped BARRYMOUNTS have been specially developed to provide assured protection for sensitive equipment against shock and vibration. An outstanding feature is their remarkably uniform performance over the full range of rated load variation.

Over 1,000,000 BARRYMOUNTS go into use *every year* for the protection of every type of airborne equipment, from the lightest and most delicate instruments and electronic devices to apparatus up to 140 lbs. weight.

There are also BARRYMOUNTS available for specialised vehicle-borne and ship-borne equipment applications.



MINIATURIZED BARRYMOUNTS ARE USED IN THE BRISTOL 'BRITANNIA'

Air-damped BARRYMOUNTS are supplied in a wide range of sizes for Rated Loads of from 0.1 to 35 lbs. We invite enquiries for special "ALL-METL" types designed for prolonged service and efficiency in aircraft at extreme operating temperatures.

☆ **ADVANTAGES**

- **Superior vibration isolation.**
- **Improved shock absorption.**
- **Low permanent set and drift.**
- **Operation over wide temperature range.**
- **Minimum side sway.**
- **Wide load range with uniform performance.**

Write for technical bulletins giving full information and performance graphs.

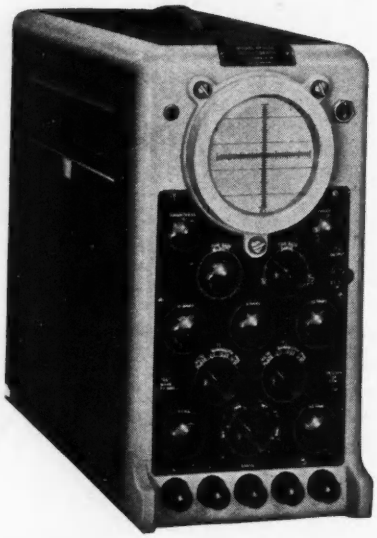
BARRYMOUNTS

CBI

European Licensees :

CEMENTATION (MUFFELITE) LTD., 39 Victoria Street, London, S.W.1 *(Tel. ABBey 5726)*

COSSOR *presents...*



The new Cossor Double Beam Oscillograph

MODEL 1052

Two similar amplifier channels with an approximate gain of 2000 and an upper frequency response of 5 megacycles (minus 6 DB) are features of this new Cossor Double Beam general purpose oscillograph. The repetitive or triggered time base has a sweep duration from 200 milliseconds to 5 microseconds.

The instrument will operate from power supplies of any of the various frequencies and voltages encountered in the Armed Services or from standard civil supply mains. The top and side panels are quickly detachable to allow inspection and a removable plate at the rear of the instrument allows access to tube plates, anode and modulator.

and Voltage Calibrator

MODEL 1433

Primarily designed to be used with the new Cossor oscillograph the Cossor Voltage Calibrator model 1433 provides an accurate means of calibration of input voltages to the plates or amplifiers of any oscillograph. Calibrating voltages are read directly from a wide scale meter without any computation being necessary. Measurements can be made to an accuracy of ± 5% and the instrument can be used in any application where a source of accurately-known voltage is required.

C1353

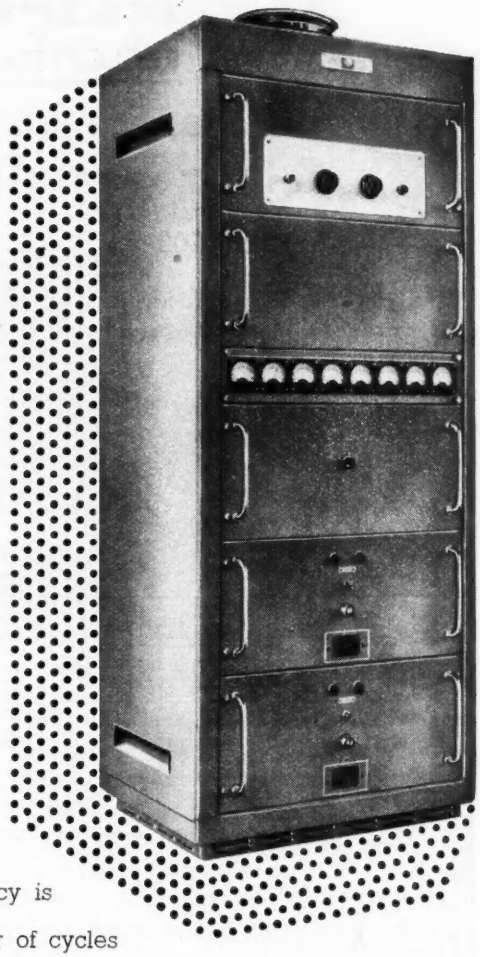
COSSOR ELECTRONIC INSTRUMENTS

Write for illustrated leaflets about both of these instruments

A. C. COSSOR LTD., INSTRUMENT DIVISION, DEPT. 2, HIGHBURY GROVE, LONDON, N.5

Telephone: CANonbury 1234 (33lines). Telegrams: Cossor, Norphone, London. Cables: Cossor, London.

ALWAYS USE COSSOR TUBES & VALVES



AUTOMATIC FREQUENCY MONITOR (20 Mc/s)

Designed for the measurement of any frequency in the range 10 c/s to 20 Mc/s with a basic accuracy of $\pm$ 1 part in 10^6 $\pm$ 0.1, 1.0, or 10 c/s. Higher accuracies available if required. The unknown frequency is determined by counting the number of cycles that pass through a 'gate' open for a selectable time interval of 0.1, 1.0, or 10 seconds. The result is presented on eight panel mounted meters each scaled 0 to 9 and is in decimal notation. Full information available on request.

CINEMA-TELEVISION LIMITED

A Company within the J. Arthur Rank Organisation

WORSLEY BRIDGE ROAD · LONDON · SE26

Telephone HITher Green 4600

SALES AND SERVICING AGENTS

F. C. Robinson & Partners Ltd., 287 Deansgate, Manchester, 3

Hawnt & Co., Ltd., 59 Moor St. Birmingham, 4

Atkins, Robertson & Whiteford Ltd. 100 Torrisdale Street, Glasgow, S.2

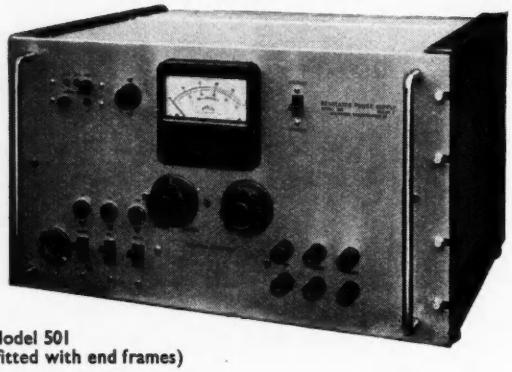
ALL-POWER

REGULATED POWER SUPPLIES

SERIES 500

An entirely new range of units, designed for the highest possible performance and overall efficiency.

Now in large scale production and available for prompt delivery.



Model 501
(fitted with end frames)

ABRIDGED DATA
(Further information on request)

	Data	Model 501	Model 502	Model 503	Model 504	Model 505
Main +VE Stabilizer	Output	200-500V 250mA	200-500V 250mA	0-500V 250mA	0-500V 250mA	0-500V 150mA
	Number of Ranges	2	2	4	4	1
	Voltage Stabilization	±0.02%	±0.002%	±0.1%	±0.002%	±0.1%
	Effective Output Resistance (max.)	0.2 Ω	0.02 Ω	0.5 Ω	0.02 Ω	0.5 Ω
	Output Ripple (rms. max.)	2mV	1mV	3mV	1mV	3mV
−VE Supply Stabilizer	Outputs	—	—	250V 25mA 0—250V 1mA	250V 25mA 0—250V 1mA	250V 25mA 0—250V 1mA
	Voltage Stabilization	—	—	±0.05%	±0.002%	±0.05%
	Output Resistance (max.)	—	—	1 Ω	0.01 Ω	1 Ω
	Output Ripple (rms. max.)	—	—	2mV	1mV	2mV
Unstabilized +VE H.T. Supply 250mA max.		470V 630V	470V 630V	320V 470V 630V	320V 470V 630V	630V
Unstabilized A.C. Supply		6.3V 10A	6.3V 10A	6.3V 10A	6.3V 10A	6.3V 10A
Price		**£70**	**£91**	**£81**	**£99**	**£75**

STANDARD UNITS. All models are supplied as standard for mounting in 19 in. racks and are fitted with fully protective covers.

EXTRAS. To convert from rack mounting to bench use the following extras are available :—

Polished hard-wood reinforced end frames ... ... **£1 15 0** per pair

Steel instrument case of new design ... ... **£4 10 0** each

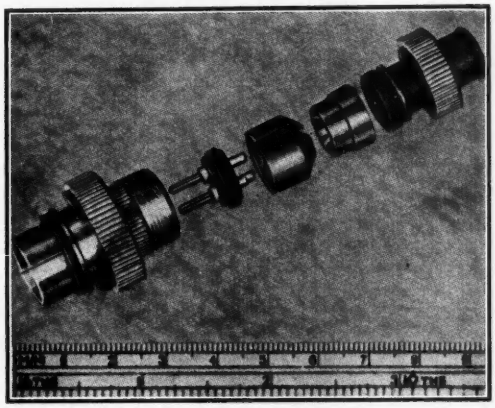
PRICES. Prices are quoted net ex works and are subject to variation without notice.

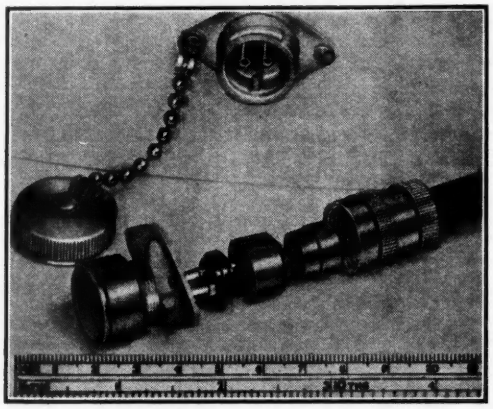
ALL-POWER TRANSFORMERS LTD. . CHERTSEY ROAD, BYFLEET, SURREY
Tel. : BYFLEET 3224/5

"SCREENECTOR" REGD.

Lightweight plugs and sockets for coaxial, 2 or 3-pole assemblies

- **Versatile**
- **Perfect contact**
- **High insulation resistance**





L 6 2 5 / C A dust cover, with the "quick" thread locking device, has been developed for use with these connectors and is supplied complete with chain attachment.

Assembly	Coaxial	Twin	3-pole
Free plug	L722/P	L625/P	L715/P
Fixed socket	L722/S	L625/S	L715/S
Adaptor bulkhead	L723	L689	L716
Free socket	L724	L690	L717

Type	Characteristic impedance, ohms*	Contact resistance at 1 amp.	*Capacitance P. & S. mated	
			Conductor/ conductor	Conductor/ screen
Coaxial	75	(less than	—	1.9 pF
2-pole	100	2 milli-	1.4 pF	2.3 pF
3-pole	—	ohms ea.)	2.0 pF	2.7 pF

**Approx. at 1 Mc/s.*

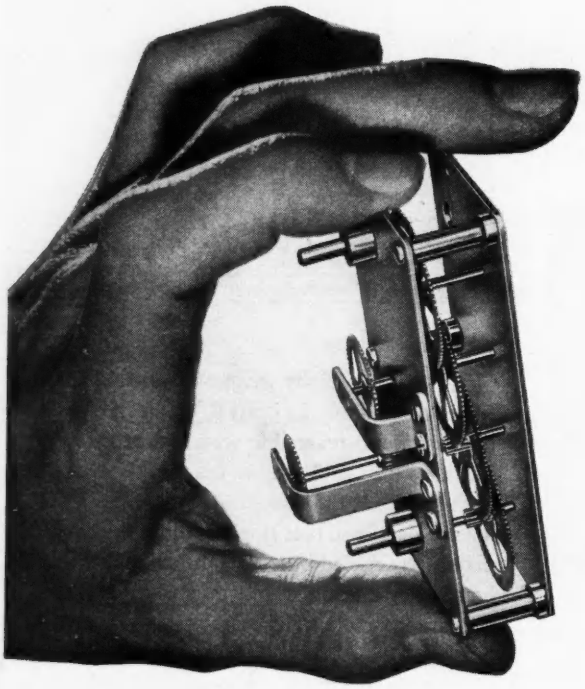
THIS range of light weight screened connectors is based upon the draft R.E.C.M.F. specification for a non-reversible screened twin plug and socket to load cables up to 0.24 in. diameter over the braid. At the same time, the design has been made versatile so that single and multiple contacts may be assembled into the common housing. This housing is machined and therefore possesses an appearance in keeping with modern instrument finish.

Although a "quick" thread locking ring forms part of the assembly, the screen skirt is resilient, thus maintaining excellent contact should the locking ring be inadvertently left loose.

The contact assembly insulator is produced from a moisture resistant nylon-filled phenolic moulding material, and the design includes lengthened leakage paths between contacts in order to maintain high insulation resistance which is 0.6×10^5 MΩ at 500 V. between pins or pins and frame.

BELLING & LEE LTD
GREAT CAMBRIDGE ROAD, ENFIELD, MIDDX., ENGLAND

FINE WORK



-in DURALUMIN

REGD. TRADE MARK

by FERRANTI

This tiny but important meter train by Ferranti Limited, is not only an example of the fine precision work carried out by that famous organisation but also demonstrates the way in which "Duralumin" can assist in developments in the electrical field.

The construction is largely in "Duralumin" manufactured to very fine tolerances and its use means that less power is required to drive the train, the accuracy of the meter thereby being increased.

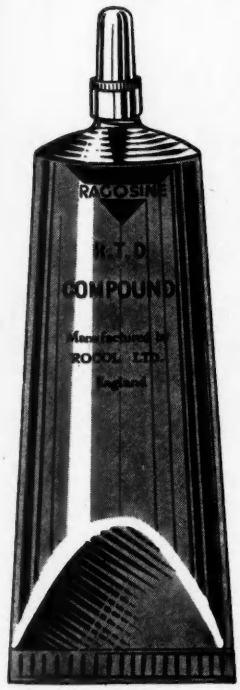
"Duralumin" is one of a comprehensive range of light alloys developed by James Booth & Company Limited, and these modern materials are being increasingly used with great advantages in electrical engineering and electronics. Our Development Department will always be pleased to offer advice entirely without obligation.

JAMES BOOTH & CO. LTD · ARGYLE STREET WORKS · BIRMINGHAM · 7

BOOTH BIRMINGHAM

"LET R.T.D.–THE BETTER CUTTING COMPOUND SOLVE YOUR PRODUCTION PROBLEMS!"

"No wonder Rocol R.T.D. Compound is a success. It's a grand cutting compound. The 100% additive it contains makes it a 'must' for all severe metal working operations."



In TUBES, TINS, and KEGS

R.T.D. Compound prevents welding of high spots and enables low micro finish and close tolerance work to be carried out with greater ease, better finish and greatly increased tool life. It is supplied in the form of a soft paste so that it can be applied direct to the tool face but, where greater penetration is required, it can be diluted with any straight cutting oil, ordinary machine oil, or even Kerosine, to meet the varying requirements of different processes.

RAGOSINE

use it for

TAPPING · DRILLING REAMING · BROACHING FRETTING · SAWING and DRAWING OPERATIONS.

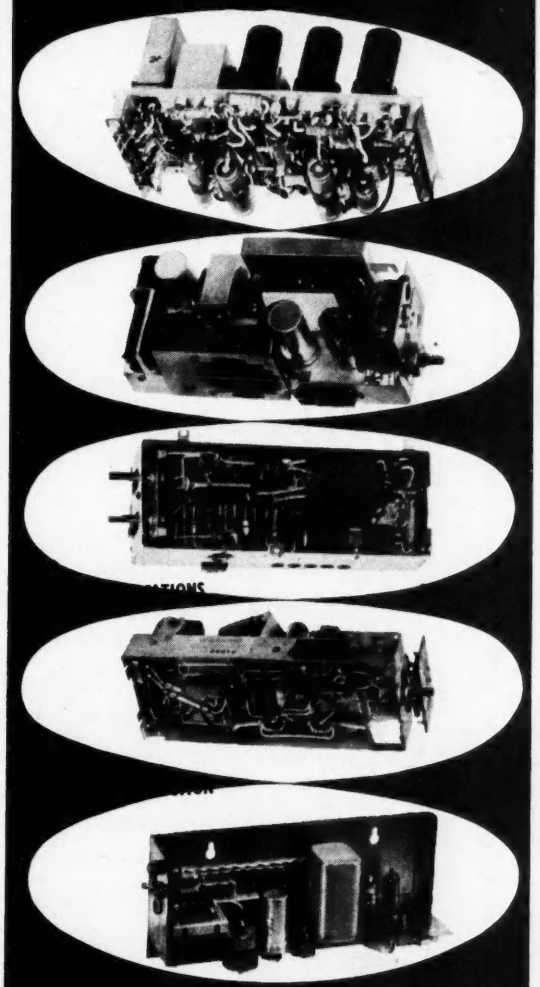
ROCOL R.T.D COMPOUND

ROCOL LIMITED

IBEX HOUSE, MINORIES, LONDON, E.C.3.
Telephone : ROYal 4372.
MINERVA WORKS, WOODLESFORD, NR. LEEDS.
Telephone : Rothwell 2164.

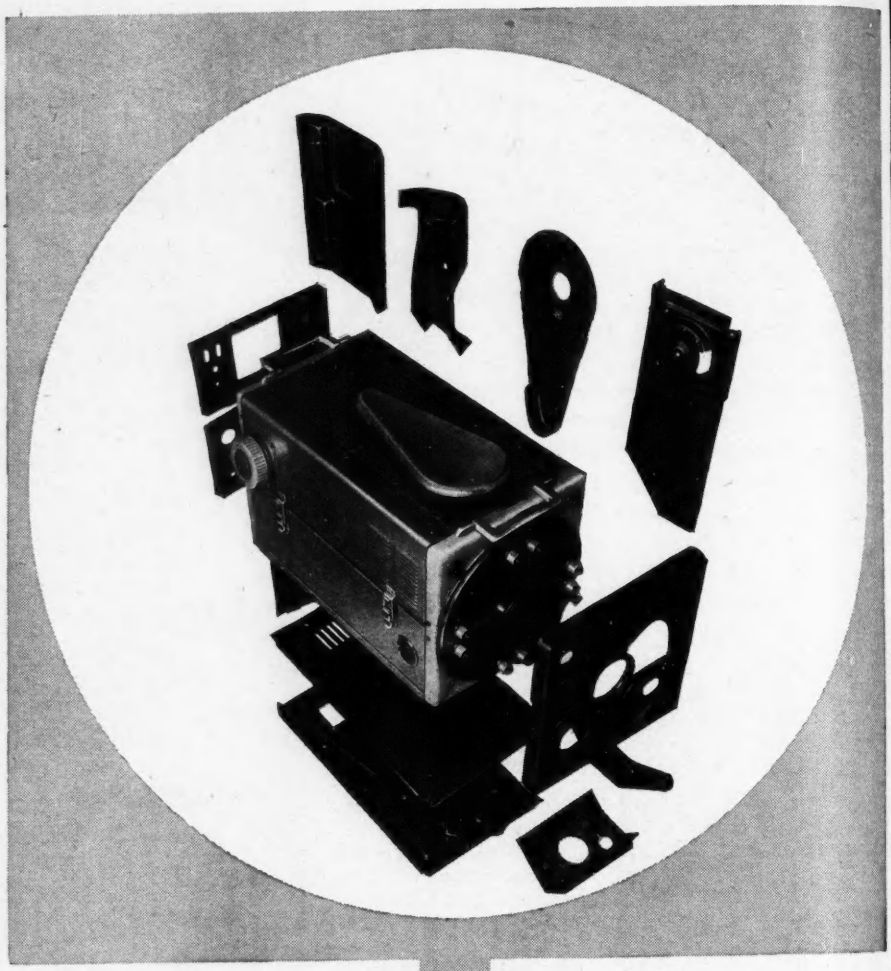
n.d.h. 21838

Electronic Assemblies by P.A.R. of Nottingham



Find out more about these other P.A.R. Products

CHOOSE ELEKTRON FOR TV CAMERAS



. . . Because it is one third lighter than aluminium . . . exceptionally strong and ensures easy handling during operation.

For all main structural parts and minor components of PYE TV CAMERAS—ELEKTRON PRESSINGS have more than proved their worth at all stages of production . . . from basic design to the finished article. ELEKTRON has high dimensional stability . . . constant temper during machining and excellent surface finish. These combined properties make Elektron Magnesium Alloys outstanding in meeting the stringent demands of modern industry. Our Technical Representative will be glad to call on you.

This advertisement was prepared with the co-operation of PYE of Cambridge.

MAGNESIUM ELEKTRON LIMITED

CLIFTON JUNCTION • MANCHESTER

LONDON OFFICE: 21 St. James's Square, London, S.W.1. Telephone: WHITEHALL 1040.

FOR UP-TO-DATE
INDUSTRIAL
LUBRICATION
& PARTING

Colloidal Graphite today

Since the discoveries of Dr. Acheson 50 years ago, the registered trade mark **'dag'** has been synonymous with colloidal graphite in its industrial applications.

'Aquadag', 'Oildag', 'Gredag' and our other marks are known throughout the engineering world and today the Acheson organisation offers unrivalled experience and facilities in the related fields of lubrication and parting, particularly under conditions of high temperature or pressure.

The unique properties of **'dag'** colloidal graphite as a dry lubricant, as an additive to oils and greases for parting and to form electrically conducting coatings are now fully recognised and we issue informative technical literature covering such aspects as :—

High-temperature lubrication · Metal-forming · Engine and machinery assembly and running-in · Parting · Wire-drawing · Impregnation · Various applications in the field of electronics.

Please write us now stating your main interests and let us send copies of any of the above without cost to you. Write to:—

ACHESON COLLOIDS LTD., 18 PALL MALL, LONDON, W.1
Telephone: WHI 2034-7. Telegrams: OILDAG-PICCY-LONDON
Also ACHESON COLLOIDS COMPANY, Port Huron, Michigan, U.S.A.

Colloidal Dispersions of Graphite, Molybdenum disulphide, Silver, Titanium dioxide and other solids, in oil, water and volatile solvents for every industrial requirement. Specific literature on request.

TAS/AC.60

Precision Cathode Ray Tubes

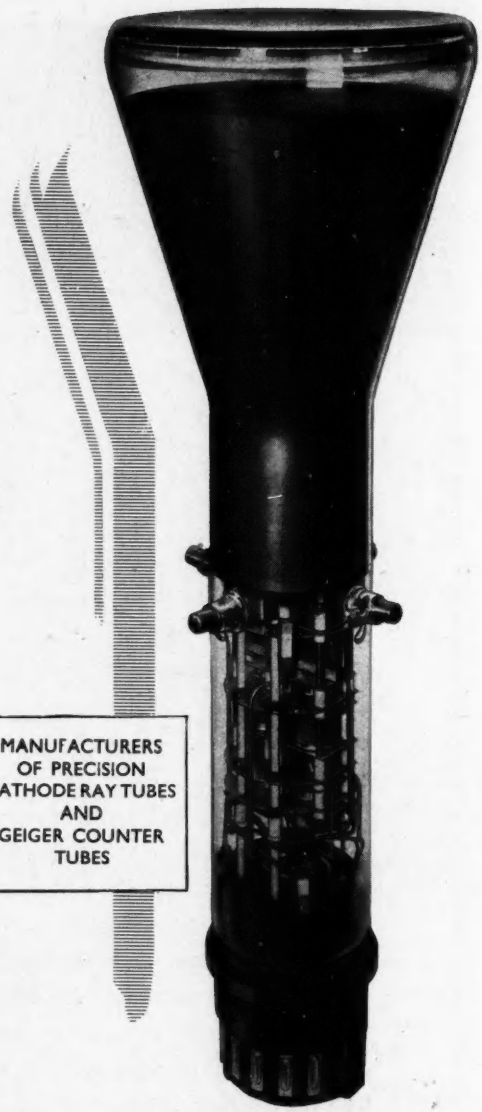
Double Beam Tubes

Series D.6 and D.4

These tubes employ two independent electron guns. All eight deflector plates are separately connected and interplate screening ensures complete absence of intermodulation. The traces can be superimposed and each gun has a useful screen area of at least 100 mm. × 80 mm. Independent connections to each grid, cathode and focus electrode permit optimum conditions of operation for each gun and each of the beams may be brightness modulated. Sweep speeds of 100 cms./μsec. may be recorded using the D6B or D4B.

		D.6	D.4
Type			
Diameter		6 in.	4 in.
Overall lengths (mms.) ...		480	370
Sensitivity	X	700	400
mm./V x VA_2	Y	700	350
Y capacity		4μμf	4μμf
Heater volts		6.3	6.3
VA_2 max. KV		5	5
VA_1 max. KV		2	2
VA_2 (VA_3=2KV) volts ...		300	300
Vg for cut-off (average) ...		—45	—45
Drive for 20μa I_B		20v	20v

Screens:
D6B — Blue for photographic or visual use.
D6G — Green for visual observations.
D6P — Medium persistence.
D6F — Fluoride. Long persistence.
D6D — Double screen. Long persistence.



MANUFACTURERS OF PRECISION CATHODE RAY TUBES AND GEIGER COUNTER TUBES

20th Century Electronics Limited

20th CENTURY ELECTRONICS LTD.

Telephone : GIPsy Hill 2277/78.

DUNBAR WORKS, DUNBAR STREET,
WEST NORWOOD, LONDON, S.E.27.

Marconi Audio Tester TF 891A

For the determination of overall frequency characteristics in the range 50 c/s to 27 kc/s.

This compact, light weight beat-frequency oscillator is directly calibrated from 50 c/s to 27 kc/s in two ranges and has a maximum power output of 2 watts into 600, 15, or 30 ohms. The frequency stability is good and the total harmonic content is of the order of 1%.

The four-range meter, which may be immediately switched from the input to the output of the equipment under test, has a frequency characteristic within ±1db. Both the meter and the built-in attenuator carry voltage and power calibrations giving a level adjustment of over 60db.

FREQUENCY RANGES:
50 c/s to 15 kc/s and 15 kc/s to 27 kc/s.

OUTPUT POWER:
up to 2 watts.

OUTPUT IMPEDANCES:
600, 15 and 3 ohms.

METER RANGES:
4, 8 and 80 volts f.s.d.

POWER SUPPLY:
100 to 150 and 200 to 250 volts, 40 to 100 c/s.

MARCONI INSTRUMENTS

SIGNAL GENERATORS · VALVE VOLTMETERS · Q METERS · FREQUENCY STANDARDS
BRIDGES · WAVEMETERS · WAVE ANALYSERS · BEAT FREQUENCY OSCILLATORS

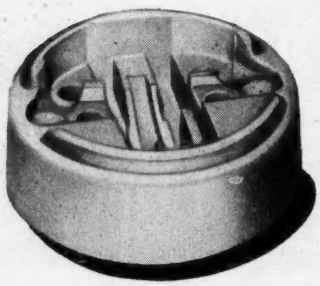
MARCONI INSTRUMENTS LTD · ST. ALBANS · HERTS · Telephone: St. Albans 6160/9

Midland Office: 19 The Parade, Leamington Spa **Northern Office:** 30 Albion Street, Kingston-upon-Hull
Export Office: Marconi House, Strand, W.C.2.

TC 49

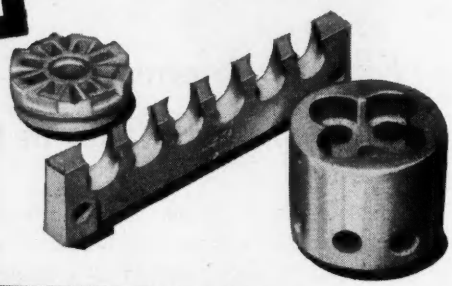
Bullers

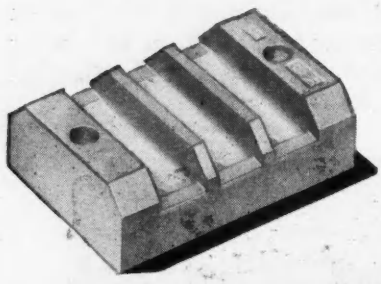
CERAMICS FOR INDUSTRY

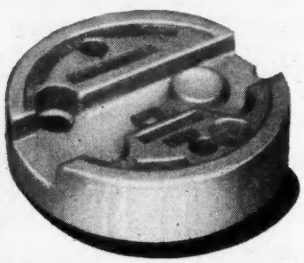


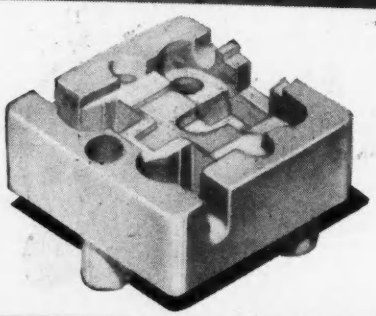
High quality material and dimensional precision are attributes of Bullers die-pressed products.

Prompt delivery at competitive prices.









We specialise in the manufacture of

PORCELAIN
for general insulation

REFRACTORIES
for high temperature insulation

FREQUELEX
for high frequency insulation

PERMALEX & TEMPLEX
for capacitors

BL10A

BULLERS LIMITED

Porcelain Works :
MILTON,
STOKE-ON-TRENT
Stoke-on-Trent 5164

Sales Office :
6, LAURENCE POUNTNEY HILL,
LONDON, E.C.4
MANsion House 9971

Iron Works :
TIPTON,
STAFFORDSHIRE
Tipton 1691

CONSTANT VOLTAGE TRANSFORMERS IN **COLORIMETRY**

-but COLOUR MATCHING to-day

depends upon

CONSTANT VOLTAGE....

In 1954 electronics provides the answer. In colour matching today, the precision instruments used must have a reliable and constant voltage supply, and this is one of the many applications Advance Constant Voltage Transformers fulfil so effectively.

Full details given in folder M15 gladly sent on request.

Advance
CONSTANT VOLTAGE TRANSFORMERS

CVT

ADVANCE COMPONENTS LTD.
MARLOWE ROAD, WALTHAMSTOW, LONDON, E.17
Telephone : LARkswood 4366

GD

Announcing the **NEW**

AIRMEC

Wave Analyser Type 853

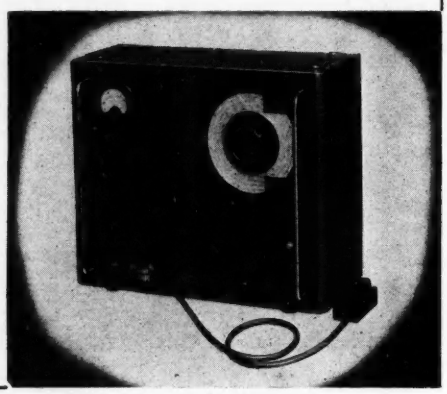
(Selective Measuring Set 30 kc/s—30 Mc/s)

This instrument is a selective measuring set of great versatility operating over the frequency range 30 kc/s-30 Mc/s. It consists essentially of a stable high-gain selective amplifier, operating on the heterodyne principle and incorporating H.F. and L.F. attenuators. The output in the form of an audio-frequency is applied to a meter circuit and to headphones.

Special features are the high sensitivity (1 microvolt up to 10 Mc/s), wide attenuator range (120 db), high accuracy of attenuation (±0.1 db overall on L.F. attenuator), high selectivity, low noise-level and continuous coverage over the whole frequency range.

It can be employed :—

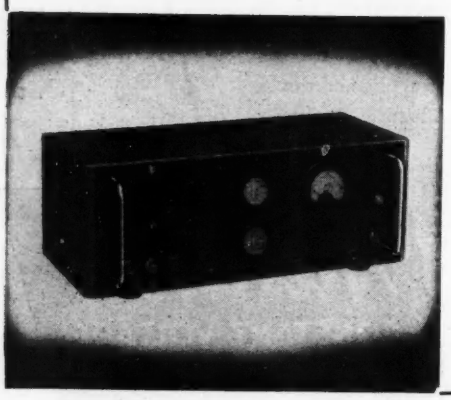
(a) **To measure insertion gain and loss.**
(b) **To measure field strength and interference.**
(c) **For harmonic analysis.**
(d) **As a selective Voltmeter.**
(e) **As a Bridge Detector.**
(f) **As a Heterodyne Wavemeter.**



Frequency range :	30 kc/s-30 Mc/s in 7 ranges.
Amplitude range :	30 kc/s-10 Mc/s. 1μV. to 120 db above 1μV. 10 Mc/s-20 Mc/s. 2μV. to 120 db above 2μV. 20 Mc/s-30 Mc/s. 4μV. to 120 db above 4μV.
Harmonic measurement :	2nd harmonics 70 db down and 3rd harmonics 90 db down can be measured.
Selectivity :	3 kc/s bandwidth.

Oscillator Type 858

The oscillator Type 858 is designed fundamentally for use as a calibrating oscillator for the Wave Analyser Type 853, and as such provides fixed levels of output suitable for setting up this instrument. It may, therefore, be used with the Wave Analyser for measurements of field strength and absolute levels of single frequency components of complex waveforms.



It may also be employed separately as a C.W. oscillator with special characteristics of very low harmonic distortion and stabilised output level.

Frequency range :	30 kc/s-30 Mc/s in 7 ranges.
Frequency stability :	Considerably better than 0.05 per cent with mains change from 200-250V.
Harmonic distortion :	In general better than 1 per cent.
Output level :	Remains constant within ±1db over complete frequency range.
Outputs :	500mV, 100mV, and 10mV. A slidewire attenuator enables a continuous output coverage to be obtained from 500μV. to 500mV, when the instrument is used on its own as a C.W. oscillator.

Full details of these or any other Airmec products will be forwarded gladly upon request.

AIRMEC LIMITED

HIGH WYCOMBE — BUCKINGHAMSHIRE — ENGLAND

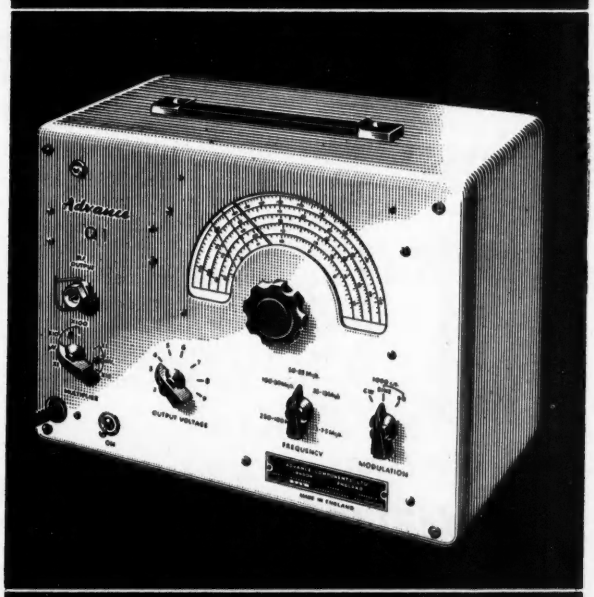
Telephone: **High Wycombe 2060** *Cables:* **Airmec High Wycombe**

ADVANCE COMPONENTS LTD., MARLOWE RD., WALTHAMSTOW, LONDON, E.17. *Telephone : LARkswood 4366.*

7·5 to 250 Mc/s
ON FUNDAMENTALS
IN FIVE RANG
SINE A
SQUARE
MODULA
R.F. OUTPUT
1 μV to 100 m

a New
SIGNAL GENERATOR
for **BAND 3**
SERVICING

Advance



MODEL Q1

Again Advance lead the way—this time with a V.H.F. Signal Generator covering 7·5 to 250 Mc/s, a range that embraces Bands 1 and 2 *and also the impending Very High Frequency Television Transmissions on Band* 3. Moreover this instrument is available at a price well within the reach of every service man.
In the traditional Advance manner this instrument is designed for simple operation and with a versatility that not only fulfils present needs, but anticipates the even more exacting requirements to deal with the television test problems of tomorrow.

Below are some outstanding features :—

- WIDE RANGE, 7·5 to 250 Mc/s
- SINE AND SQUARE WAVE MODULATION *(internal and external)*
- RELIABLE ATTENUATION
- LOW LEAKAGE—*less than 3 microvolts*
- TRULY PORTABLE—*weighs only 17 lbs.*
- COMPETITIVE PRICE

Full technical details available in Folder M 23 on request

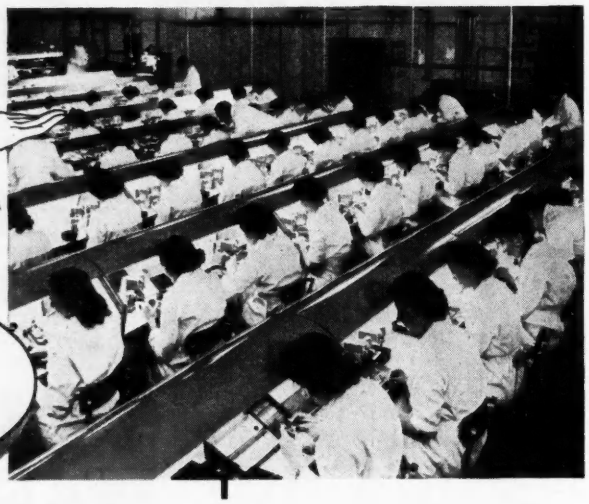
£45
(List price in U.K.)

The Q1 provides the ideal complement to the Model E2. These together give complete coverage from 100 kc/s to 250 Mc/s.

ADVANCE COMPONENTS LTD., MARLOWE RD., WALTHAMSTOW, LONDON, E.17. *Telephone : LARkswood 4366.*

GD

We see to it...



BRIMAR VALVES

are more reliable than EVER!

Rigid control of production processes, a ready acceptance of improved manufacturing techniques, and continual vigilance in the analysis and selection of raw materials ensure that every BRIMAR valve will do its job more efficiently . . . more reliably.

Modern manufacturing methods backed by an intensive research and development organisation enable BRIMAR to anticipate and meet the changing demands of the radio and electronic industries. There is bound to be a BRIMAR valve to exactly meet YOUR specification.

The 12AT7 is a very reliable frequency changer and is widely used in modern TV receivers, VHF and UHF communications equipment. It is also frequently employed in industrial equipment, computors, navigational aids and test equipment.

now is the time to ***BRIMARIZE!***

BRIMAR	MULLARD	MARCONI OSRAM	COSSOR EMITRON
12AT7	ECC81	B152 & B309	12AT7

Use the BRIMAR 12AT7 with improved performance at NO EXTRA COST

Standard Telephones and Cables Limited

FOOTSCRAY, KENT. FOOtscray 3333

Introducing

A NEW RANGE OF TRANSFORMERS SPECIALLY DESIGNED FOR THE ELECTRONICS INDUSTRY

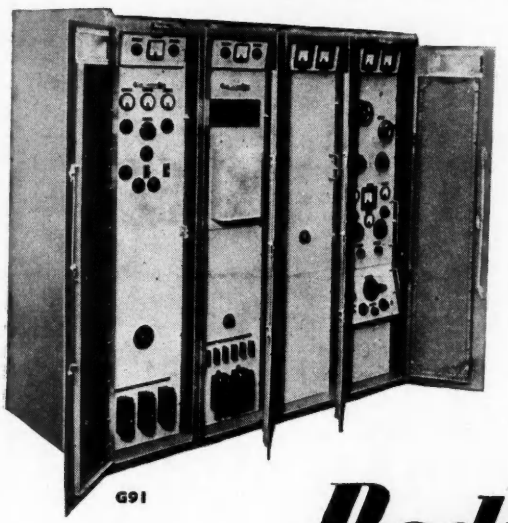
DESIGNED & MANUFACTURED BY :-

RADFORD Electronics LIMITED

IF YOU USE TRANSFORMERS, SEND FOR OUR VERY INFORMATIVE BROCHURE WHICH WILL ASSIST YOU IN YOUR WORK.

149 • NEWFOUNDLAND ROAD • BRISTOL • 2

Telephone— BRISTOL 51132



In the service of

BRITAIN'S FASTEST MODERN AIRCRAFT

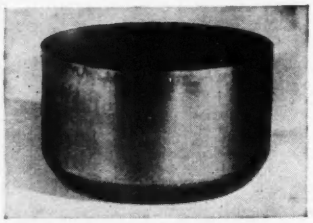
With long range beacon services for International air routes installed at many key points on the new Empire routes . . the Redifon G.91 and its HF equivalent G.67, are providing navigational and communication services for Britain's latest high speed aircraft.

Redifon

Aviation Communications Division,
REDIFON LIMITED • BROOMHILL ROAD • LONDON, S.W.18 • 'Phone VANdyke 7281
A Manufacturing Company in the Rediffusion group.

NARITE

THE *NEW* METAL FOR PRESS TOOLS AND DRAWING DIES



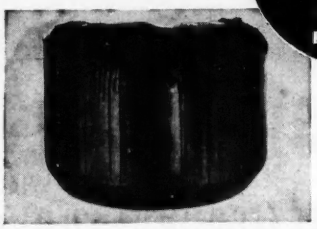
THESE TWO PHOTOGRAPHS ILLUSTRATE SIMILAR PRESSINGS MADE UNDER IDENTICAL CONDITIONS. THAT ON THE LEFT SHOWS THE PERFECT RESULTS OBTAINED WITH NARITE DIES, COMPARED WITH THE WASTER PRODUCED BY ORDINARY STEEL DIES.

LESS WEAR
LESS WASTERS
MORE PRODUCTION
MORE PROFIT

Un-retouched Photographs by Courtesy of a NARITE User

WRITE FOR BROCHURE

NARITE eliminates 'scuffing,' 'galling,' or 'wrinkling' in pressing. NARITE gives lower die costs, more press production hours, more profit. NARITE service is yours for the asking.



Write now to :

CW 2431/12

N C ASHTON LIMITED

ST. ANDREW'S RD. HUDDERSFIELD
Telephone : HUDDERSFIELD 6263/4.

THIS CONSOLE IS IN OUR STANDARD RANGE

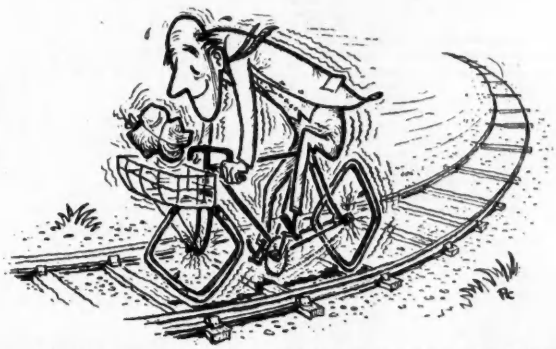
Reg. Des. No. 870016 and 7

It is robustly constructed and has excellent ventilation.
Front panels of 10 S.W.G. steel
bolts to standard G.P.O. drillings
The top is of grey linette,
burn proof, formica.
Chassis runners and handles
can be supplied as an extra.
It is one of our range of standard metal cabinets, cases, racks and consoles.

SEND TO DEPT. C
for illustrated Catalogue
of our standard range.

IMHOFS 112-116 NEW OXFORD STREET, LONDON, W.C.I. MUSEUM 7878

VIBRATION TESTING ?



No, we do *not* recommend this method! We offer, instead SAVAGE 'VLF' and 'LRF' Amplifiers, giving

A SOURCE OF POWER

where it is required for vibration and fatigue testing of structures, components, engineering products, engines, special metals, etc. In this direction, the applications of this equipment are countless, as they are, also, as a *variable frequency power source* for transformers, meters, motors and electrical component design.

This equipment is inexpensive to purchase, simple and economical to use; gives complete and accurate control at all times.

Ask us TO-DAY for full details, without obligation. Or let us know your problem in this field and we will gladly help you.

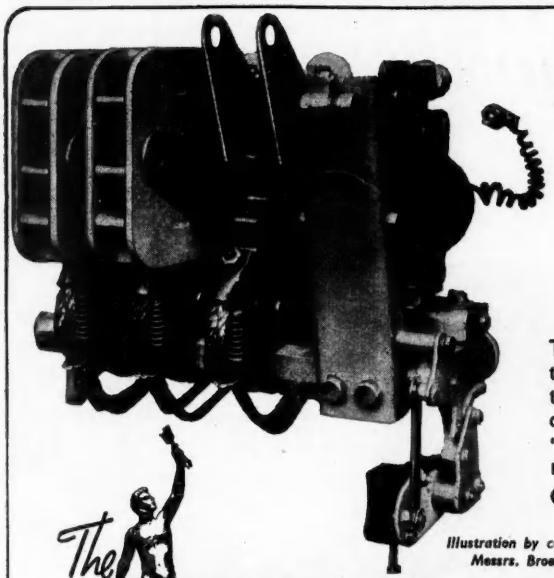
W. BRYAN SAVAGE LTD.
WESTMORELAND ROAD, LONDON, N.W.9
TELEPHONE: COLINDALE 7131

Leading organisations now using this equipment include: Bristol Aeroplane Co.; The Brush Electrical Engineering Co., Ltd.; English Electric Co., Ltd.; Ferranti Ltd.; G.E.C.; Handley Page Ltd.; The Imperial College of Science; Siemens Bros. & Co., Ltd.; S.T.C.; Vickers-Armstrongs; R.A.F., Farnborough, etc.

W. BRYAN **Savage**

V.L.F & L.R.F AMPLIFIERS
VERY LOW FREQUENCY — LOW RADIO FREQUENCY

OUTPUTS
100 watts 'VLF'
3 c/s to 6 c/s
1000 watts 'VLF'
6 c/s to 2000 c/s
MARK II STAR
50 c/s to 10 Kc/s
'LRF'
5Kc/s to 100 Kc/s



When Designing

SWITCH and CONTROL GEAR

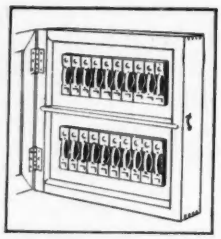
Two essentials are looked for in the contacts to be used. Firstly, the material specification, and secondly, the precise workmanship of the contact unit itself. "Thessco" and "Thessconite" contacts meet all requirements in the electrical field.

Contacts literature supplied on request.

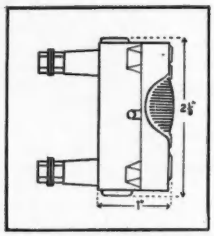
Illustration by courtesy Messrs. Brookhirst Switchgear Ltd.

The **SHEFFIELD SMELTING Company Limited**

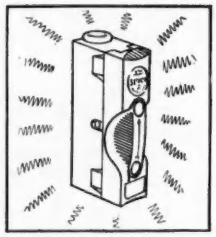
SHEFFIELD · **LONDON** · **BIRMINGHAM**
ROYDS MILL STREET, SHEFFIELD, 4 Phone: 26511
1, BERRY ST., CLERKENWELL, LONDON, E.C.1. Phone: CLE 3156
4, 5 & 6, WARSTONE LANE, BIRMINGHAM, 18. Phone: Central 6893



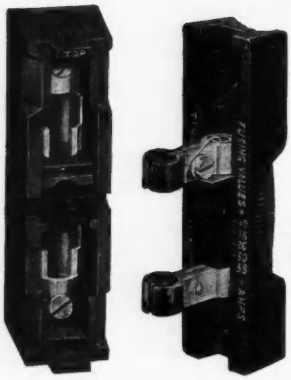
MINIMUM DIMENSIONS



EASE OF MOUNTING & WIRING



VIBRATION & SHOCK PROOF



To simplify and protect . . .

Slydlok X type fuses afford the designer complete freedom because their ease of wiring, their compactness, and above all their resistance to mechanical shock, enables them to be incorporated wherever convenient. Adaptable for cartridge fuses and neutral links, Slydloks afford protection with simplicity. Write for literature.

SLYDLOK FUSES

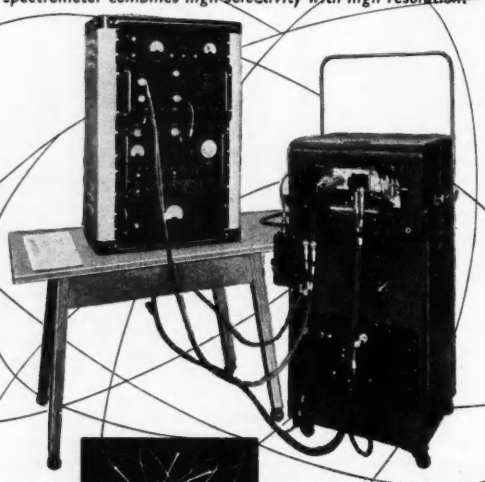
EDWARD Wilcox & CO. LTD., WYTHENSHAWE, MANCHESTER.

Tel.: WYThenshawe 2235/6/7. *'Grams:* Slydlox Manchester

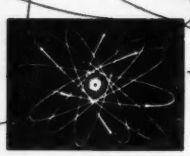
dm EW.54

ELECTRO-MAGNETIC IDENTIFICATION *of inorganic & organic molecules*

V.I.A. *mass spectrometer combines high selectivity with high resolution.*



This mass Spectrometer is of high sensitivity and accuracy, and provides identification of inorganic and organic molecules of mass numbers 16—90. The minimum of variable controls throughout the full scale of recording, contributes towards trouble-free service. The Spectrometer is of the 180° focussing type with fixed magnetic field of 1500 Gauss and a varying accelerating voltage.



VIA-VAC

Specialist manufacturers of industrial vacuum—consulting service to industry.

VACUUM INDUSTRIAL APPLICATIONS LTD., WISHAW, LANARKSHIRE

This is what an

M.R.S.T., Assoc. I.E.E., M.Brit. I.R.E.
F.T.S., A.Mus.T.C.L., M.I.M.I.T. ★

says about the

TRUVOX

TAPE DECK MARK III

"The Truvox Tape Deck is a winner . . . the best I have heard, disregarding the price. . . . a fine piece of precision engineering."

22 GNS.

A TRUVOX PRODUCT

★ *Mr. J. G. C. Gilbert pictured here with his complete "lash up" recorder, is Head of Northern Polytechnic Dept. of Telecommunications Engineering. He is better known to the public as John Gilbert of the B.B.C. Inventors' Club.*

The Deck is supplied with complete details of an amplifier specially designed to achieve maximum efficiency.

TRUVOX LIMITED, Sales Office,
15 Lyon Road, Harrow, Middx.

Please send me full details of the TRUVOX Tape Deck Mark III.

Name .....

Address .....

E.E.

GUIDED WEAPONS

The Guided Weapons Department of

Vickers-Armstrongs Limited, Weybridge,

has vacancies for the following Staff :—

GRADUATE ENGINEERS, with Degrees in Engineering, Physics or Mathematics, and 3 to 5 years' experience in one of the following categories :—

E.1. Design and development of high-pressure hydraulic or pneumatic systems and components.
E.2. Development of techniques for vibration and/or climatic testing as applied to electronic equipment and design of associated test gear.
E.3. Development work on reinforced plastics.
E.4. Design of missile autopilots, simulators and computors.
E.5. Design of U.H.F. and Micro-wave Transmitters and Receivers.
E.6. Design of transformers and magnetic amplifiers, with good general knowledge of electrical properties of materials.
E.7. Design of electronic circuits and servo mechanisms.
E.8. Engineering development of missile electronic equipments.

TECHNICAL ASSISTANTS, with Degree, Higher National Certificate or equivalent, and experience in one of the following categories :—

T.1. Development and test of high-pressure hydraulic or pneumatic systems and components.
T.2. Environmental testing of missile components.
T.3. Manufacture of prototype missile electronic equipments to M.O.S. specifications.
T.4. Manufacture of reinforced plastic components and potting of electronics.
T.5. Development and test of instrumentation for missile trials.
T.6. Development of missile autopilots and analogue computers.

LABORATORY ASSISTANTS, preferably with O.N.C. or equivalent.

L.1. Assembly, test and maintenance of hydraulic and pneumatic systems and components.
L.2. Drawing and constructing test rigs used for mechanical and environmental testing.
L.3. Manufacture of prototype electronic equipment and electro-mechanical devices. Layout and wiring from circuit diagrams and sketches, chassis work and simple machining.

DRAUGHTSMEN, with two years' experience or more, as follows :—

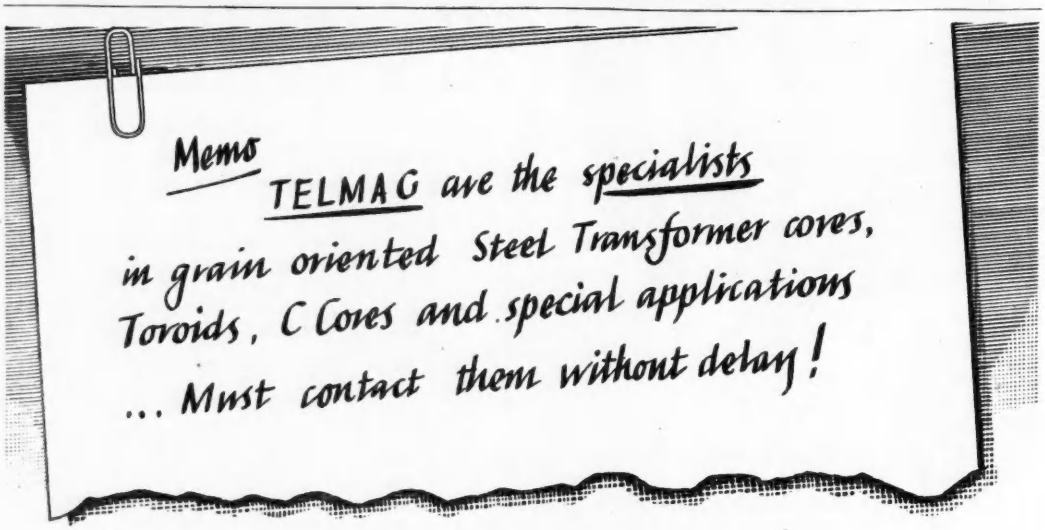
D.1. Design of ground airborne or missile types of radar equipment.
D.2. Design of small mechanisms such as missile autopilots, and electro-mechanical computors embodying gyroscopes, accelerometers, small motors, gearboxes, etc.

Apply to Employment Manager, Vickers-Armstrongs Limited (Aircraft Division), Weybridge, Surrey, giving full particulars and quoting reference EO/G.W./reference number above.

Weybridge station is 30 minutes from London on the main Waterloo/Portsmouth line.

Additional buses operate to and from the Works at starting and finishing times. Canteen facilities.

1953.


Memo
TELMAG are the specialists
in grain oriented Steel Transformer cores,
Toroids, C Cores and special applications
... Must contact them without delay!

Please write for technical literature, available upon request.

TELMAG ADVISORY SERVICE

We maintain a specialised advisory service and are always pleased to co-operate on any specific problem.

TELCON-MAGNETIC CORES LIMITED

CHAPELHALL INDUSTRIAL ESTATE, CHAPELHALL, LANARKSHIRE. Tel.: AIRDRIE 2283

Continuously variable from 150 v. to 10 kv.

(NON-LETHAL)

E.H.T. INSULATION TEST SET
TYPE XU 110

Leakage loss under E.H.T. conditions in cables, conductors, etc., may be measured on the meter, which also indicates voltage, by the turn of a switch.
The instrument is of laboratory standard, yet is portable enough for use in the field.

Full details and specification from the Manufacturers :

TELEMECHANICS LTD.

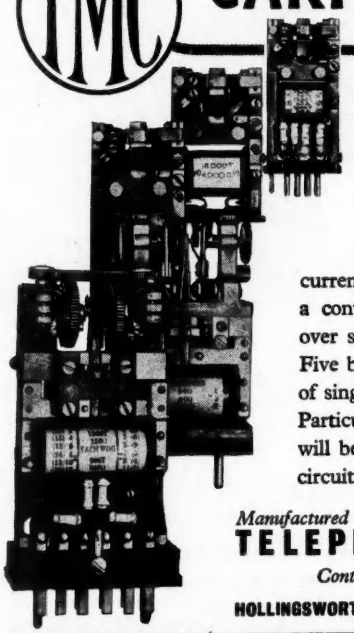
INSTRUMENT DIVISION • 3, NEWMAN YARD, NEWMAN STREET, LONDON, W.1.

TELEPHONE: LANgham 7965

TMC

CARPENTER POLARIZED RELAYS

—have these outstanding features



The Carpenter Polarized Relay will respond to weak, ill-defined or short-duration impulses of differing polarity, or it will follow weak alternating current inputs of high frequencies and so provide a continuously operating symmetrical change-over switch between two different sources.
Five basic types are available with a wide range of single and multiple windings.
Particulars of the type best suited to your purpose will be gladly supplied if you will send us your circuit details.

- **High operational speed**
- **High sensitivity**
- **Freedom from contact rebound**
- **No positional error**
- **High contact pressures**
- **Accuracy of signal repetition**
- **Exceptional thermal stability**
- **Ease of adjustment**

Manufactured by the sole licensees.

TELEPHONE MANUFACTURING CO. LTD

Contractors to Governments of the British Commonwealth and other Nations

HOLLINGSWORTH WORKS • DULWICH • LONDON S E 21 • Tel: GIPsy Hill 2211

The I.D.L.

WIDE BAND AMPLIFIER

and Discriminator - Unit Type 652

Designed primarily for use with Scintillation counters. This unit is a wide band width linear pulse amplifier of high stability with built-in discriminator.

GAIN: 80 dB. BAND WIDTH: 5 Mc/s

Variable rise and fall time

DISCRIMINATOR BIAS: 5-50 volts (metered)

Full particulars of this and ancillary nucleonic equipment from:

ISOTOPE DEVELOPMENTS LTD.

ISOTOPE DEVELOPMENTS LIMITED · 120 MOORGATE · LONDON · E.C.2. Telephone: METropolitan 9641 (5 lines)

Midland Agent: **Hawnt & Co. Ltd.**, *59, Moor Street, Birmingham, 4. Tel: Central 6871*

Northern Agent: **A. M. Lock & Co. Ltd.**, *Crompton Street, Chadderton, Oldham, Lancs. Tel: Main 6744*

Scottish Agent: **A. R. Bolton & Co. Ltd.**, *72, Haymarket Terrace, Edinburgh, 12. Tel: Edinburgh 62446*

Technical Control

Close technical control of production is an all-important factor in the manufacture of Telcon Metals. Accurate tests and measurements are made at various stages in the course of production and the illustrations show two of the many routine examinations conducted in our well-equipped laboratories.

Precision measurement of magnetic characteristics of toroidal Mumetal cores by the Ferrometer.

Routine Factory testing of Mumetal toroidal cores.

TELCON METALS

MAGNETIC ALLOYS — Mumetal, Radiometal, H.C.R., Rhometal, Permendur, R2799, 36/64, Dust.

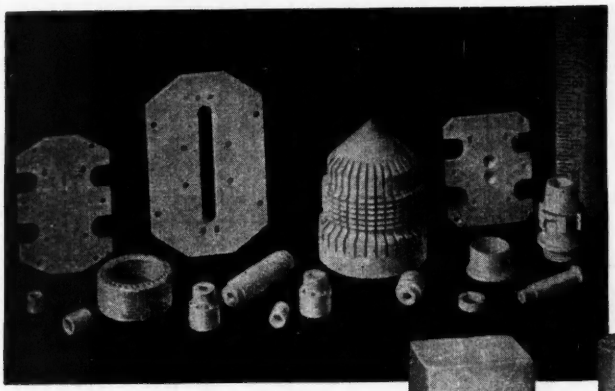
RESISTANCE ALLOYS — Pyromic, Calomic, Telcuman, Telconstan, Telconal.

SPECIAL ALLOYS — Thermostatic Bimetals 140, 400, 15, Telcoseal, Invar, Beryllium-Copper.

The Telegraph Construction & Maintenance Co. Ltd

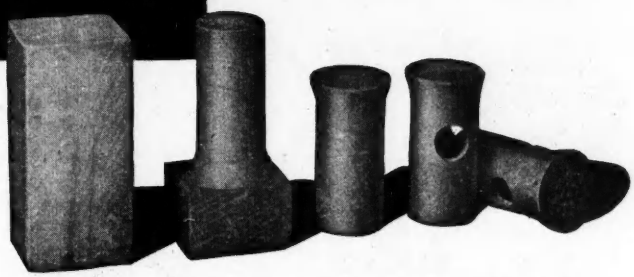
Head Office: 22 Old Broad Street, London, E.C.2
Telephone: LONdon Wall 7104

Enquiries to: Telcon Works, Greenwich, London, S.E.10
Telephone: GREenwich 3291



STEATITE

... for all high frequency applications



Over a century of experience in this highly specialised field. We invite your enquiries.

Machined to special designs and fine limits.

SUGG WESTMINSTER

WILLIAM SUGG & COMPANY LIMITED

VINCENT WORKS, REGENCY STREET, WESTMINSTER, S.W.1. VICtoria 3211

Electrical Standards for Research and Industry

Testing and Measuring Apparatus for Communication Engineering

Unapproached throughout the world for design and accuracy

WAVEMETERS

OSCILLATORS

CONDENSERS

INDUCTANCES

RESISTANCES

BRIDGES—Capacitance Inductance Resistance

H. W. SULLIVAN LIMITED
LONDON, S.E.15
Telephone: New Cross 3225 (P.B.X.)

Some MEN don't seem to understand—

the importance of the welfare side from
THE WOMAN'S ANGLE

By the simple depression of a lever THE BARRYWALD SANITARY INCINERATOR will automatically and effectively destroy sanitary towels, surgical dressings, documents, etc., solving vital and major welfare and security problems in FACTORIES, OFFICES, INSTITUTIONS, etc.

Δ The only Incinerator incorporating our Patented Safety Devices

The BARRYWALD
Safety Automatic Incinerator

Patent Nos. 555062-621085 and corresponding Foreign Patents

Awarded the Certificate of the Royal Institute of Public Health and Hygiene

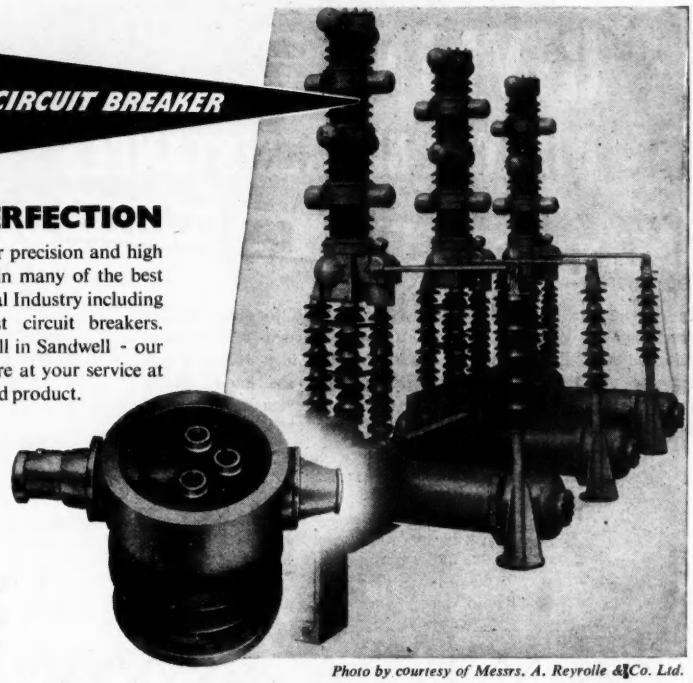
Regularly supplied to :—All H.M. Government Departments ; War Office ; R.A.F. ; Admiralty. Local Administration & Educational Authorities. Hospital Management Committees. General Industry.

FULLY GUARANTEED FOR ONE YEAR
Economical : Efficient : Foolproof : Indispensable

THE FOREMOST SANITARY INCINERATOR SPECIALISTS IN THE WORLD

SANIGUARD APPLIANCES *Limited*
62. LONDON WALL. LONDON. E.C.2
Telephones :— NATIONAL 8881-8882 • DIVISION OF ALLIED METALS LTD

"...& on the REYROLLE CIRCUIT BREAKER



MORE PARTS OF PERFECTION

Sandwell castings are renowned for their precision and high tensile strength, and are incorporated in many of the best known products throughout the Electrical Industry including Reyrolle 132 kV. 3,500-MVA air-blast circuit breakers. Where only the best castings will do, call in Sandwell - our specialised knowledge and experience are at your service at all stages from the blueprint to the finished product.

by SCC

THE SANDWELL CASTING CO.

Bank Street Foundry, West Bromwich
Tel: STOnecross 2231 (4 lines).
Grams: "Repcast" West Bromwich

Photo by courtesy of Messrs. A. Reyrolle & Co. Ltd.

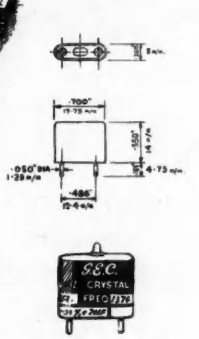
★ *Specialists in the production of the finest quality Sand Castings, Gravity Die Castings and Pressure Die Castings in all Light Alloys and Non-Ferrous Metals by the most modern methods.*

---

for unfailing activity

G.E.C.
SUB-MINIATURE
QUARTZ
CRYSTAL
UNITS

Q.C. 500
Frequency range
10,000 Kc/s to 16,000 Kc/s

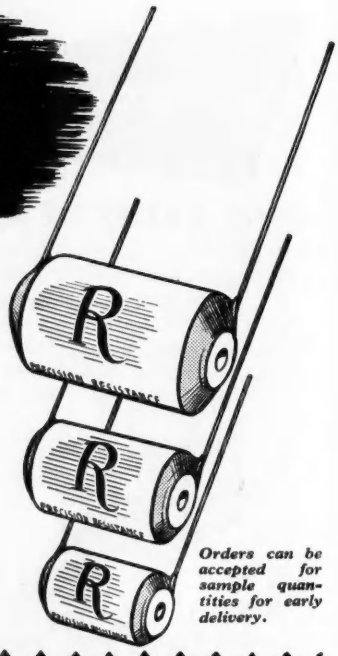


Type BA, frequency change not exceeding 0.01% from 0°C to +70°C
Type DA, frequency change not exceeding 0.01% from −30°C to +45°C
Type EA, frequency change not exceeding 0.002% from +65°C to +80°C

For further details please apply to:-

SALFORD ELECTRICAL INSTRUMENTS LTD
PEEL WORKS • SILK STREET • SALFORD 3 • LANCS
A Subsidiary of THE GENERAL ELECTRIC CO. LTD. OF ENGLAND

RIVLIN *Precision*
WIREWOUND RESISTANCES
FOR EARLY DELIVERY



In response to the steadily increasing demand for high quality precision Wire Wound Resistances, Rivlin Instruments offer a range designed specially for those applications where high accuracy and extreme stability are essential. Made from the finest quality materials, these Resistances are completely impervious to the effects of humidity and temperature.

- Rivlin Resistances can be adjusted to .1% of the required value, or ± .01 Ω whichever is the greater.
- Any value in the range .1 Ω to 50,000 Ω can be supplied with a temperature co-efficient of .002% per degree centigrade, and up to 1 MΩ with a temperature co-efficient of .02% per degree centigrade. Standard rating — 1 watt.
- Rivlin Wire Wound Resistances fully comply with Services specifications.

Orders can be accepted for sample quantities for early delivery.

Rivlin Instruments Ltd., 7a Maitland Park Villas, London, N.W.3. *Phone : Gulliver 2960*

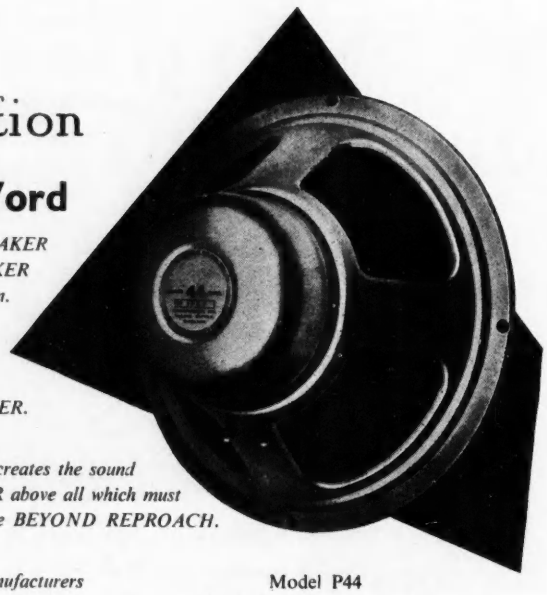
Rola Celestion

The Final Word

In all radio reproduction it is the LOUDSPEAKER which has the Final Word. It is the LOUDSPEAKER which finally determines the quality of reproduction.

The finest radio receiver in the world can only give indifferent results if fitted with an indifferent LOUDSPEAKER.

It is the LOUDSPEAKER which re-creates the sound and it is the LOUDSPEAKER above all which must be BEYOND REPROACH.



Model P44
Lightweight 12″ Loudspeaker

We have loudspeakers for every purpose and set manufacturers are invited to collaborate with us on all problems relating to sound reproduction.

Rola Celestion Ltd.

FERRY WORKS,
THAMES DITTON, SURREY
Telephone : Emberbrook 3402-6

. . . Its plain sailing

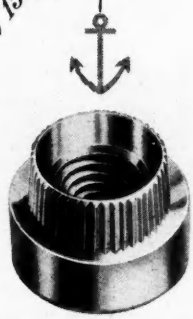
fastening to thin Sheet metal

with . . .

PRECISION
PATENT SERRATED
Anchor
RIVET
Bushes

Manufacturers of all kinds of products use this method of fastening to metal sheets and panels. Note the serrations on the finely tapered shank — these cut their way into the sheet and prevent the bush from rotating in the panel.

Ask for Illustrated Leaflet 154

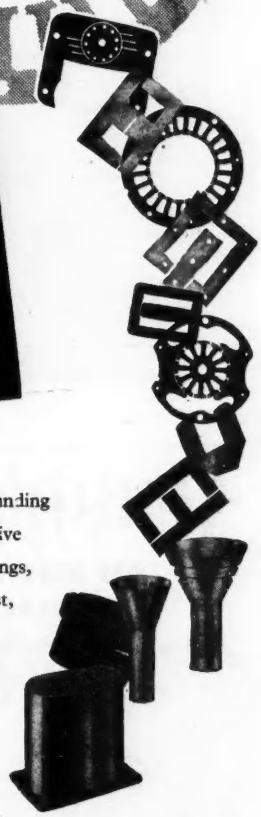


THE PRECISION SCREW & MFG. CO. LTD
UNION ST. WILLENHALL STAFFS

Telephone : WILLENHALL 621 & 622

For Quality in the Core

Electrical **STAMPINGS** *and Magnetic* **SCREENS** *by* **MEA** *remain unequalled*



Pacing progress in the ever expanding field of Electronics, the extensive M.E.A. range of standard toolings, plus special patterns on request, are available in all grades of Silicon and Nickel Iron Alloys. Your requirements, standard or special, will receive immediate attention.

MEA

The following catalogues are available : Transformers and Choke Stampings, F.h.p. Motor Stampings, Magnetic Screening Tubes and Cases, Nickel Iron Alloys Data on request to our Head Office, Dept. FH/K.

For Service to Science and Industry throughout the field of Electronics

MAGNETIC & ELECTRICAL ALLOYS LTD.

HEAD OFFICE : 101-103, BAKER ST., LONDON, W.1. Tel : Welbeck 3381/2.
WORKS : BURNBANK, HAMILTON, LANARKSHIRE. Tel : Hamilton 932/3/4.
MANCHESTER : 33 BYROM STREET, DEANSGATE. Tel : Blackfriars 5223.
BIRMINGHAM : 6, MILL STREET, SUTTON COLDFIELD, WARWICKSHIRE, Tel: Streetly 78586.
FH

Permanent Magnets
for the
Radio & T.V. Industry

Made by the makers of
'Eclipse'
Permanent Magnet Chucks

The very latest techniques in permanent magnet manufacture can effect real economies in your production and at the same time contribute further to efficient operation of your products. Consult our Technical Staff at an early stage of design to be certain that you are taking advantage of recent progress.

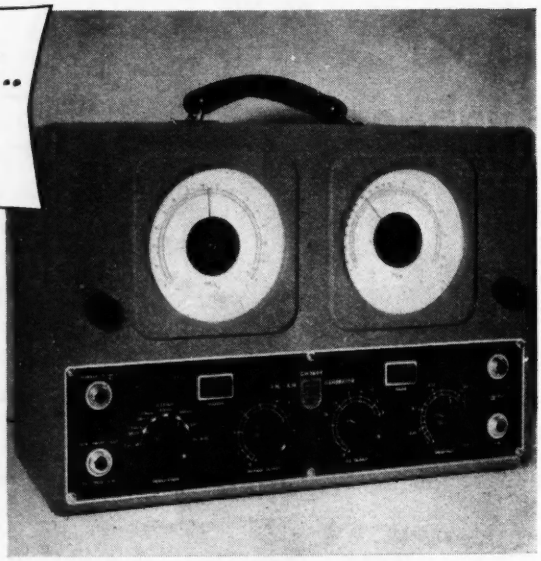
Send for literature:
Pub. PM108—Loud Speaker Magnets.
Pub. PM112—Permanent Magnets for Television Receivers.

Eclipse **PERMANENT MAGNETS**

JAMES NEILL & CO. (SHEFFIELD) LTD.,
SHEFFIELD, 11 ENGLAND
MB

PHILIPS *present...*

GM 2889 A.M. F.M. SIGNAL GENERATOR



Band 3 for TV.

Are your laboratories suitably equipped to investigate the many problems relating to the design of receivers to handle commercial television on Band 3? One of the essential pieces of test gear is an AM/FM Signal Generator, such as GM.2889.

Features :—

1. **Frequency range 5-225 Mc/s in one band.**
2. **Marker oscillator 15-30 Mc/s.**
3. **A.M. Modulation int. 400 c/s ext. 0-10 Mc/s.**
4. **F.M. Modulation sweep 0-15 Mc/s.**
5. **Output impedance 75 and 300 ohms.**

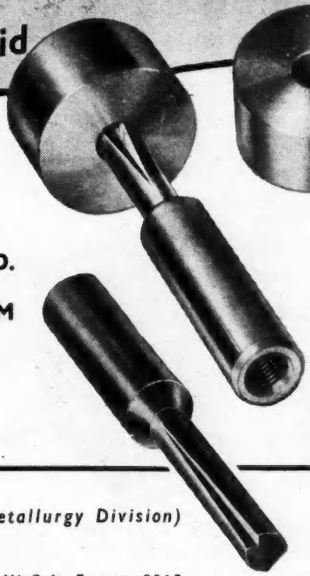
INDUSTRIAL X-RAY EQUIPMENT · ELECTRONIC APPARATUS
LAMPS AND LIGHTING EQUIPMENT · ARC AND RESISTANCE
WELDING PLANT AND ELECTRODES · MAGNETIC FILTERS
BATTERY CHARGERS AND RECTIFIERS · H.F. HEATING
GENERATORS · RADIO AND TELEVISION RECEIVERS

PHILIPS ELECTRICAL LTD.
INDUSTRIAL DIVISION
CENTURY HOUSE · SHAFTESBURY AVENUE · LONDON · W.C.2

(PI 410 REV.)

ZIRCONIUM VALVE SEATS & PLUGS

for Hammel-Dahl valves controlling the flow of 28°Tw. Hydrochloric Acid



. . . FABRICATED BY

J. BLAKEBOROUGH & SONS LTD.

& MUREX LTD. from ZIRCONIUM

supplied by Murex Ltd.

MUREX LIMITED *(Powder Metallurgy Division)*

RAINHAM • ESSEX • *Rainham, Essex 3322*

London Sales Office: CENTRAL HOUSE, UPPER WOBURN PLACE, W.C.1 *Euston 8265*

74/8

For **precise stable MEASUREMENT**

OF MEAN AND DYNAMIC *pressures*

and RECORDING

with

Recording Camera, Oscilloscope or Direct Writing Recorder

Self-contained for measurement of mean pressure, this versatile A.C. mains-operated electro-manometer has one single pressure head for positive and negative pressures, and output sockets for *all* types of recording equipment. Developed from *hospital* requirements in analysis of heart and artery pressures, it incorporates the latest technique for *industrial* measurement of rapidly changing pressures.

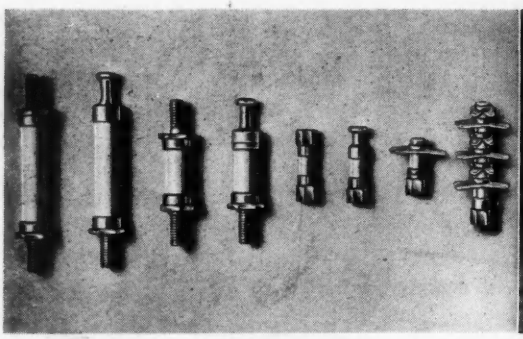
Its capacity-type pressure head of low volume displacement and inherent high-frequency response is temperature-compensated and linear within 2 per cent. over each of five ranges: 4—10—40—100—400 mm./Hg. Power supplies are electronically stabilised.

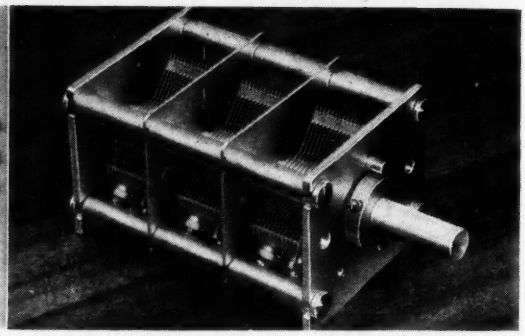
Literature and further details promptly supplied on application and inquiries regarding *individual* requirements gladly answered.

CAPACITY-TYPE N.E.P. Electro-Manometer

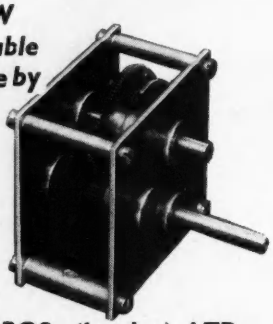
NEW ELECTRONIC PRODUCTS LIMITED, 9 NEW CAVENDISH STREET, LONDON, W.1 (WELbeck 1421-2)

Contractors to the Ministry of Supply, Ministry of Health, U.S.A.F., etc. A.I.D.-approved





They're NEW
They're reliable
They're made by
JACKSONS



JACKSON BROS. (London) LTD.,
KINGSWAY · WADDON · SURREY
Phone: CROydon 2754/5. Grams: Walfilco, Souphone, London.

STAND OFF INSULATORS

Low loss Ceramic Insulation siliconed to ensure negligible surface leakage. Meticulous construction gives remarkable resistance to shock and vibration. Range of 16 standard types available to cover your most exacting requirements. Working voltages from 1,000 to 5,000 v. Chassis space 6 BA and 4 BA. Overall height from $\frac{7}{16}$" to $1\frac{5}{16}$".

GEARED DRIVE UNIT TYPE G.I.

Precisely 56.25-1 ratio. This provides for band spreading in 28 bands. The low speed driven shaft is extended each end for pointer and take off. The high speed drive shaft is extended at rear for motor drive.

Spring loaded split gears and spring loaded self aligning ball bearings ensure permanent freedom from back lash or play in any bearing.

The final drive gear is loaded to 24 oz. in. torque. The self aligning ball bearings for all shafts are a novel and very special feature which makes this unit suitable for any application where accurate measurement of angular movement is desired.

GANG CONDENSER TYPE I.R.

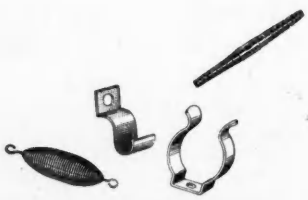
Designed to meet requirements of high grade communications equipment. Heavily constructed frame. Rotors insulated on low loss ceramic shaft. Frame members of low expansion alloy to match temperature co-efficient of rotor shaft. Capacity E Law up to 532pf swing.

THE RECIPROCATING TOGGLE THEN ACTUATES THE PLUNGER IMPELLER

It's as clear as that, except for endless modifications and sleepless nights sorting out production difficulties. The spring part can be left to Lewis, of course. That has become a habit in the last thirty-five years.

Established 1919

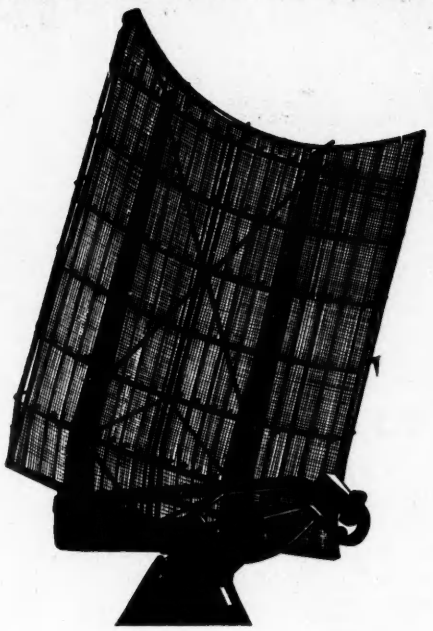
A.I.D. approved



LEAVE IT TO
Lewis
OF REDDITCH
SPRINGS, SPRING CLIPS
PRESSWORK, WIRE FORMS
VOLUTE SPRINGS

THE LEWIS SPRING COMPANY LIMITED
RESILIENT WORKS, REDDITCH. **Tel: Redditch 720/1/2**
London Office: 321 High Holborn, W.C.1. *Tel: Holborn 7470 and 7479*

MAXIMUM RESISTANCE TO CORROSION • STRENGTH • NON-MAGNETIC



TURBINE BLADING
TRANSFORMERS
OUTDOOR STRUCTURES
SWITCH FARMS
TRANSMISSION
SWITCH GEAR
RADAR EQUIPMENT

The corrosion-resistance, non-magnetic properties and mechanical strength of "Staybrite" steels are solving major problems for the electronic engineer just as they have for specialists in the fields of power generation and distribution. Examine the unique features of the "Staybrite" family of steels against your problem.

FIRTH-VICKERS

"Staybrite Steel"

IDEAL METAL FOR ELECTRICAL APPARATUS IN THE NEW FIELDS AS IN THE OLD

FIRTH-VICKERS STAINLESS STEELS LTD., SHEFFIELD
Telephone No. Sheffield 42051

ERICSSON TELEPHONES LTD.

HAVE VACANCIES FOR

Senior and Junior Research and Development Engineers and Draughtsmen

to work in their Research Laboratories at Beeston, Nottingham. Posts are available in rapidly expanding departments engaged in work on nucleonic equipment, valve developments, electronic switching and computing, and mechanical design and engineering of prototypes of apparatus, including preparation of drawings to IDP13.

Posts offer excellent prospects of promotion; applicants for research posts should have an honours degree or equivalent, and for senior posts must have several years' experience in appropriate work.

Applications, giving details of age, qualifications, experience and desired starting salary, to:

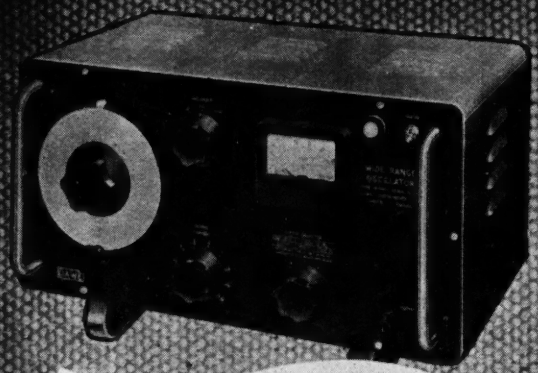
PERSONNEL OFFICER, ERICSSON TELEPHONES, LTD.
BEESTON, NOTTINGHAM.

DAWE

Wide Range OSCILLATORS

A series of resistance-tuned oscillators of low distortion

TYPE 400A 20 c/s — 20 kc/s 1 watt output
TYPE 400B 20 c/s — 200 kc/s 100 mW output
TYPE 400C 0.1 c/s — 1000 c/s 100 mW output



NOW AVAILABLE FOR PROMPT DELIVERY!

Technical data from: DAWE INSTRUMENTS LTD., *Instrument Division*
99 UXBRIDGE ROAD, EALING, LONDON, W.5 · EALING 6215
or from your Regional Agent

Midlands	North of England	Cheshire	Scotland	West of England	Northern Ireland
Hawnt & Co., Ltd., 59, Moor Street, Birmingham, 4 *Central* 6871	A. C. Farnell, Ltd., 15, Park Place, Leeds, 1 *Leeds* 32958	F. C. Robinson & Ptnrs., 287, Deansgate, Manchester, 3 *Deansgate* 6601	Land, Speight & Co., 73, Robertson Street, Glasgow, C.2 *Central* 1082	Radford Electronics Ltd., 1-9, Newfoundland Rd., Bristol, 2 *Bristol* 51132	James Lowden & Co., 11 Middlepath Street, Belfast. *Belfast* 57518

✻ THE LATEST IN *HIGH SPEED RECORDING*

Instantly....

....the record is in your hand

Accurate and instantaneous and with fixed stylus!

✻ With this unique method, there are no problems of lag or attenuation. All wave forms, including square waves, are accurately and immediately reproduced — even thousands of cycles per second — and all with the utmost simplicity.

Compare this with time-consuming and costly photo-records!

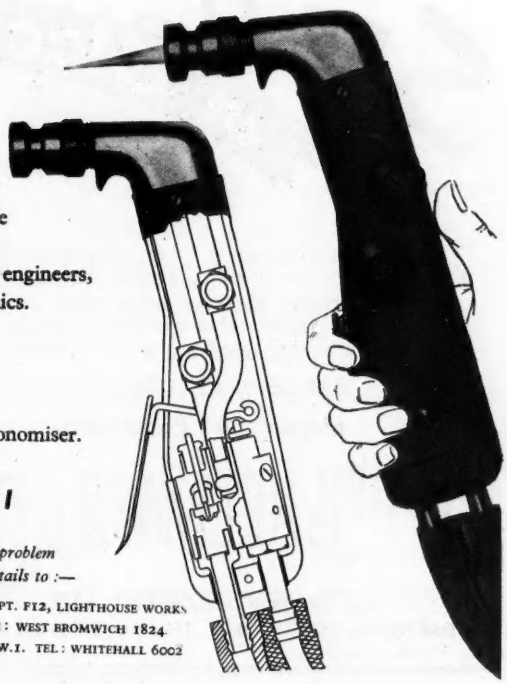
Write for information to :

DOBBIE McINNES LTD. BROOMLOAN ROAD, GLASGOW, SCOTLAND.

Illustrated is our Flush Mounting Electro-Magnetic Counter with five figures. Details of this and other models are given in our leaflet EM.

COUNTING INSTRUMENTS LTD.
5 ELSTREE WAY, BOREHAM WOOD, HERTFORDSHIRE
Telephone: ELSTREE 1382 (4 lines) Cables: COUNTHOR BOREHAMWOOD

Where will it turn up next?



The Flamemaster torch turns up in the most unlikely places and among a surprising number of trades. Our books show that glass blowers, laboratory technicians, jewellers, dental mechanics and all kinds of metal workers were among the first to welcome this precision heating tool, and that recently we've had orders from model engineers, electrical engineers, lead-burners and garage mechanics.

Why do they all find the Flamemaster so handy ?

Because: Installation is extremely simple.
Flame control is easy and reliable.
Waste is eliminated by our trigger grip economiser.
Leaks are impossible.

FLAMEMASTER MARK II

A Chance PRODUCT

If you'd like to deal with your heating problem in the up-to-date way, write for full details to :—

CHANCE BROTHERS LIMITED, DEPT. FI2, LIGHTHOUSE WORKS SMETHWICK 40, BIRMINGHAM. TELEPHONE: WEST BROMWICH 1824
LONDON OFFICE: 28 ST. JAMES'S SQUARE, S.W.1. TEL: WHITEHALL 6002

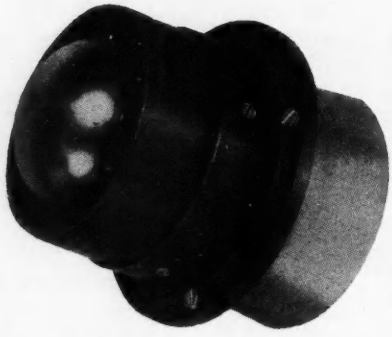
MINIATURISATION

Let us handle your cooling problems

The fan illustrated is one of our range of ELECTRONIC, AIRCRAFT, INDUSTRIAL *and* MARINE FANS. Its performance :—

50 cfm. Free Air.
40 cfm .4" swg. or 25 cfm. 1" swg.
115 V 400 c/s 3 phase
Working Temp. Range $+85°C$ $-40°C$
13 oz. weight $2\frac{1}{2}$" *diameter.*

Special low inertia, low consumption rotor moves a mass of air corresponding to 4 times the total weight of the fan per minute.



Highest efficiency axial flow fans developed for :
ANY MOTOR, ANY CONDITIONS, ANY MATERIAL, ANY QUANTITIES.

Engineered in accordance with K114, RCS1000 *or other relevant Ministry specification.*

Consult us on the following problems
CORROSION-PROOF FANS, HEAT EXCHANGERS, FILTERS, TRUNKING, GENERAL VENTILATION.

TO APPROVED MINISTRY SPECIFICATIONS

A. K. FANS LIMITED

20 UPPER PARK ROAD · LONDON · N.W.3

Telephone: PRIMROSE 5969

CONTRACTORS TO ADMIRALTY, M.O.S., etc. MANUFACTURERS OF 'AIRMAX' PATENTED SCREW FANS.

SEE IT in Black & White!

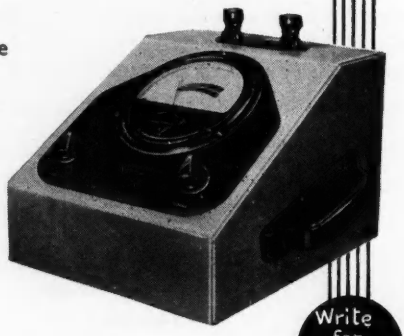
by using a

VISUAL NULL INDICATOR

No more headphones ! No more guessing ! Here is a *Visual* null indicator for A.C. Bridge work. Highly sensitive—very robust to withstand considerable overload — avoids acoustic shock. Operates on A.C. mains.

RANGE 40 c/s to 20 kc/s

Elegant • Portable



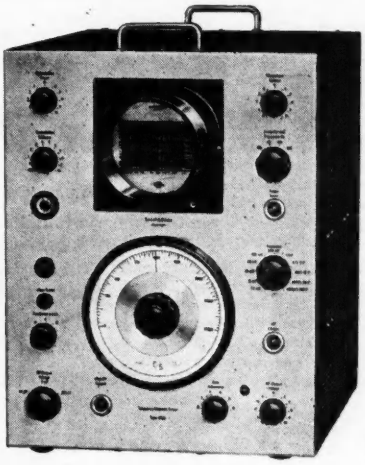
BALDWIN

INSTRUMENT COMPANY LTD.

DARTFORD, KENT • TEL. Dartford 2948/9 & 2940

Write for leaflet E114

FREQUENCY RESPONSE TRACER



type 4708/7 shows the frequency response of the equipment being examined on the screen of a long after-glow C. R. T. The A. F. voltage used for the investigation is taken from a built-in B. F. O., whose scale, together with a potentiometer for the X-deflection, is dreven by a motor, giving the X-axis a logarithmic frequency calibration. The output of the equipment being examined is fed to the Y-deflection amplifier, which has a logarithmic response over a range of 50 db and a zero level of 1 mV. Scanning speeds of 3, 6 or 12 sweeps/min. can be selected for the whole frequency range of 20-20.000 c/s. Easy and quick *visual* control of large numbers of microphones, speakers, telephones, amplifiers, filters, transmission lines, etc., can thus be made.

Model 4708 has a 1 Mc/s R. F. Oscillator modulated by the A. F., while Model 4707 has an Automatic Volume Control with a 45 db regulating range instead, so that output voltages, currents or sound-pressures can be kept constant during investigations.

For detailed information please write to:

B K

Brüel & Kjær

Adr. Nærum, Denmark . Telephone: Nærum 500 . Cable: Brukja, Copenhagen

LONDON OFFICE: ROCKE INTERNATIONAL LTD., 59 UNION ST., S.E.I. Phone: HOP 4567.

Is your problem PLASTIC MOULDINGS?

Designers and manufacturers of Electronic equipment to customers Requirements. Fully co-operate with research engineers.

Specialists in the manufacture of precision thermoplastic and thermosetting mouldings.

BARRINGTON PRODUCTS

(LEICESTER) LTD.

48, Cank Street, LEICESTER.

TELEPHONE: LEICESTER 21323

TELEGRAMS: "BARPRO" LEICESTER

We have our own fully equipped tool room

We can do it!

HALF-A-MILLION soldered joints on black enamelled wire every week. This has been our average load for a very long period—and most of it on communications and electronic equipment handled for main contractors whose names are household words.

We shall be pleased to show enquirers the very specialised facilities we have developed for handling all wiring, assembly, and test operations on both large-scale production runs and on prototype development jobs. We are A.I.D. approved, and normally work to Government and Service standards.

BROXLEA PRODUCTS LIMITED

High Rd., Broxbourne, Herts. Phone: Hoddesdon 3091/2.

'NIFORGE' *Stress-free Castings*

with properties approaching a forging

The Parlanti Mould process for stress-free castings bridges the gap between casting and forging. Close control over heat transfer at every point gives an effect very similar to a forging. The mechanical properties of Niforge castings are outstanding—fine grain structure, great tensile strength, excellent finish, freedom from porosity.

Send for this Booklet

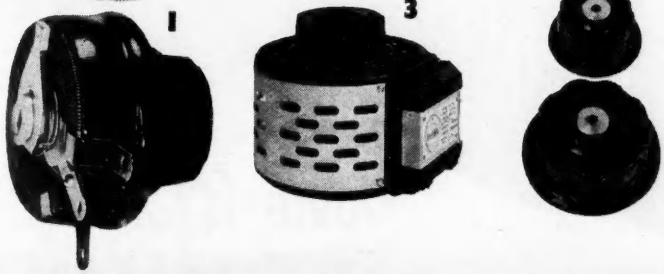
CARRON

CARRON PARLANTI LTD

CARRON PARLANTI LTD · CARRON · Falkirk · STIRLINGSHIRE
Tel. Falkirk 35. London Office: 15 Upper Thames Street, E.C.4. Telephone: CEN. 7581

G17

3 New Components
FOR THE ELECTRONICS INDUSTRY



1 **Bercostats.** A new range of power rheostats for industrial electronics. 5 sizes from 25 to 150 watts. All ceramic construction. Windings embedded in vitreous enamel giving great mechanical strength. Finishes comply with RCS.1000. Available in open, protected and ganged models.

2 A range of 3 moulded knobs with collet fitting (Patent applied for) ensuring positive grip of circular shafts. Quickly and easily fixed and removed. Interchangeable collets for $\frac{1}{4}$", $\frac{5}{16}$" and $\frac{3}{8}$" shafts.

3 **Berco Rotary Regavolt Variable Transformers.** Two additions to the range of well known "Regavolt" regulating transformers, but of rotary type, for 200/250 volt supplies, ratings 0·8 and 2 amps respectively. Compact, smaller than any other transformer of comparable rating. Suitable for panel mounting.

**See these and our wide range of high quality electronic components including:—*
Hermetically sealed potentiometer, fully Type Approved to Class H.I. of RCS.121. Vitreous enamelled resistors, also Type Approved to Class H.I. of RCS.111.

THE BRITISH ELECTRIC RESISTANCE COMPANY LIMITED

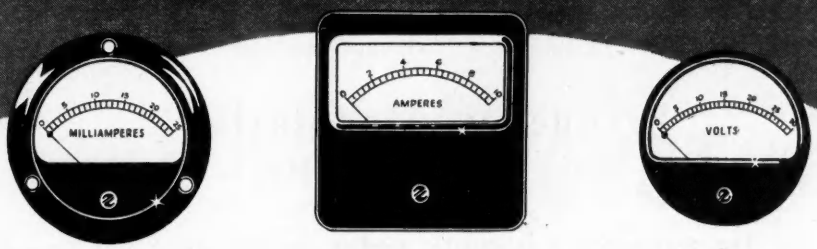
QUEENSWAY, PONDERS END, MIDDLESEX. TEL: HOWARD 1492. 'GRAMS: "VITROHM, ENFIELD"

BERCO

BR 1091—BXH

AMP VOLT

METERS



- Early delivery of small batches to special requirements.
- D.C. and A.C.
- Flush and Projecting types.
- All types to B.S.S. 89 and K113
- Suppliers to M.O.S., Admiralty, etc.
- Leaflet E-101 on request.

BALDWIN *scientific instruments*

BALDWIN INSTRUMENT COMPANY LTD., DARTFORD, KENT TELEPHONE 2948

HADDON

FULLY A.I.D. APPROVED

TRANSFORMERS LTD.

27-37 MASONS AVENUE,
WEALDSTONE, MIDDX.

Telephone :
HARROW 9022/3/4/5.

POWER and
AUDIO FREQUENCY
TRANSFORMERS

Open or Enclosed Types — For all climatic conditions

CONTRACTORS TO ALL GOVERNMENT DEPARTMENTS

IT is admitted that the present reception of the BBC's medium and long wave transmissions is most unsatisfactory in many parts of the country.

The BBC is proposing to remedy these conditions by erecting a chain of some 51 V.H.F. stations, and it is almost certain that F.M. will be the type of modulation chosen.

The principle of Frequency Modulation technique is discussed fully in :—

"Frequency Modulation"

By K. R. STURLEY, Ph.D., M.I.E.E.

Price **2/6** (postage 2d.)

The construction of a suitable receiver for the existing F.M. transmissions from Wrotham is described in :—

"A Home-Built Frequency Modulated Receiver"

By K. R. STURLEY, Ph.D., M.I.E.E.

Price **4/6** (postage 3d.)

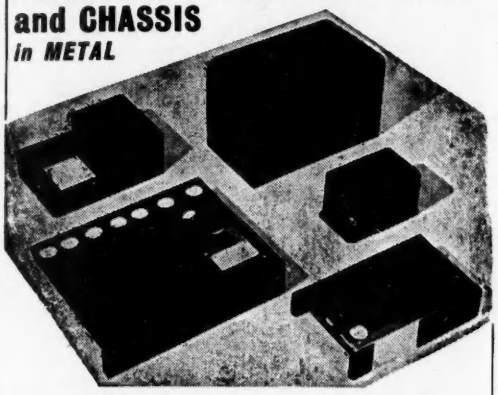
These and other monographs are obtainable from

28 ESSEX STREET, **Electronic Engineering** **STRAND, LONDON, W.C.2**

Manufacturers of all types of

SCIENTIFIC INSTRUMENT CASES and CHASSIS

in METAL



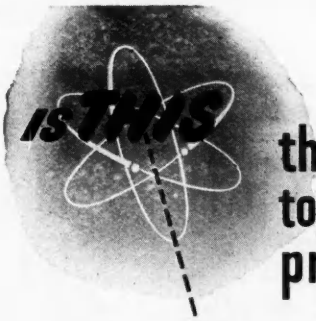
GENERAL SHEET METAL WORK

for the Trade

CHASE PRODUCTS (Engineering) LTD

27 PACKINGTON RD., SOUTH ACTON, W.3

Acorn 1153-4 *and at LEEDS*



the answer to *your* problem?

'SINTREX' Electrolytic Iron Powder has solved many problems in electronics. Its exceptional purity gives it excellent electro-magnetic properties—ensuring high permeability and low losses in components such as small transformer cores, pole pieces, etc., for radio, T.V., fluorescent units, measuring instruments and much other equipment.

'SINTREX'

ELECTROLYTIC IRON POWDER

GEORGE COHEN SONS & CO. LTD

BROADWAY CHAMBERS · LONDON · W.6

Telephone: Riverside 4141

THE 600 GROUP OF COMPANIES

RS/533/SP4

In six grades from soft to rock hard, and four qualities from medium grey to superfine, high-quality white, our range of polishing bobs includes the ideal wheel for every class of work. Send to-day for our free, illustrated brochure.

COOPERS FELT

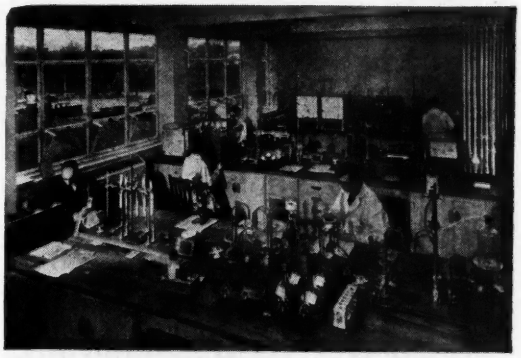
Please send all enquiries to Head Office and Works:

COOPER & CO. (B'ham) Ltd.

BRYNMAWR, BRECONSHIRE

Tel.: Brynmawr 312 *Telegrams: Felting Brynmawr*

Registered Office & Works: Little King Street, Birmingham, 19



CYGNET ***LABORATORY FURNITURE***

" CYGNET " Benches, with heat and acid-resisting tops ; Racks, Fume Cupboards, Cabinets and Shelving are made in a large range of standard units or to specification. Complete installations or single pieces for Electronic, Chemical, Physical and other Laboratories at keen prices. Built to meet the most exacting demands.

Recent contracts include installations for :—

Scottish Oils Limited · University of Sheffield · British Nylon Spinners, Pontypool · Revertex Ltd., Harlow, Essex · De Havilland Aircraft Co. University of Manchester · Ferranti Limited, Edinburgh

Experience enables us to recommend " FIBROLENE " chemical resistant flooring for laboratories. Send for full details now.

CYGNET JOINERY LTD., Higher Swan Lane, BOLTON. *Bolton 1840/4*

Scottish Agents:—

Scottish Instrument Co. Ltd., 4-7 Teviot Place, Ed'nburgh I. *Tel: BYPass 3552*

C 2

For *High Speed* SOLDERING

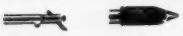
Wolf
Electric
SOLDERGUNS
& SOLDERING IRONS

Unbeatable from every point of view, well able to withstand hard workshop treatment and ideal for continuous use. Features include rapid constant localised heat—solid sturdy construction—low current consumption—perfect balance—absolute dependability. A type and bit for every purpose from fine instrument to heavy industrial work.

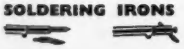
Each tool includes 5 feet tough rubber 3-core cable.

ALTERNATIVE TYPES AVAILABLE

SOLDERGUNS



SOLDERING IRONS



TRIGGER FEED SOLDER GUN

Type No. 51 is designed specially for all assembly operations. Solder is fed automatically with trigger-action and two reels are supplied—one 15 ft. acid-cored and one 15 ft. resin-cored.

Obtainable from all leading tool merchants and factors.

Fully descriptive Brochure free on request.

WOLF ELECTRIC TOOLS LTD · PIONEER WORKS · HANGER LANE · LONDON · W.5

To PERIVALE 5021 · BIRMINGHAM · MANCHESTER · LEEDS · BRISTOL · NEWCASTLE · GLASGOW

To Designers and others interested in . . .

★ **Alloys for Glass to Metal Seals** with Expansion Co-efficients to absolute Values

★ **Pure Metals and Alloys** for Vacuum, Thermionic and X-Ray Tube manufacture

★ **Bi-Metals and Thermo-Expansion Alloys**

★ **Electrical and High Temperature Resistance Wires, Strip and Tapes**

IMPORT DIVISION OF . . .

The TETRA Engineering Co., Ltd.

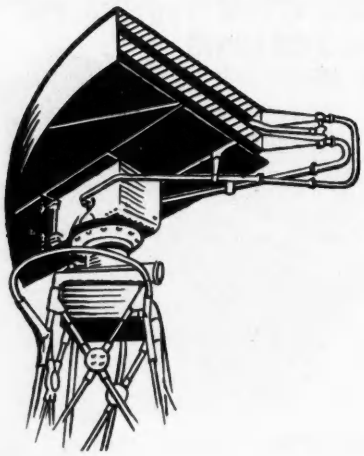
Representing

HERAEUS VACUUMSCHMELZE A.G. and ISABELLEN HUETTE

(*Makers of the Original Manganin Alloy*)

1-3 REDHILL STREET, LONDON, N.W.1.

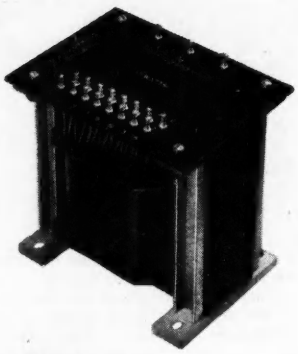
Telephone: EUSton 3707 PBX Telegrams: Tetcraft, Norwest, London



now — more than ever

SAVAGE TRANSFORMERS

are meeting the specialists need in every electronic field. Our 26 years of research & experience is at your disposal.



SAVAGE TRANSFORMERS OF DEVIZES LIMITED

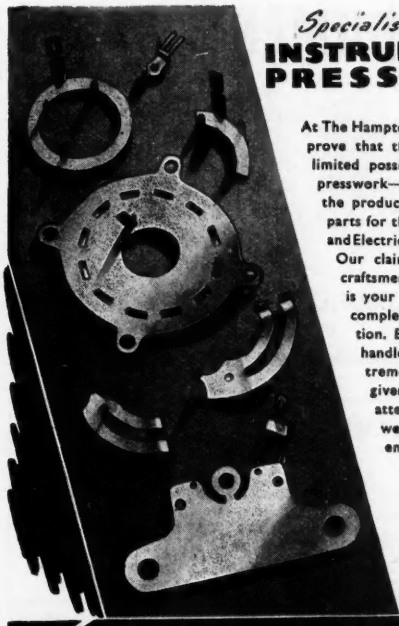
NURSTEED RD., DEVIZES, WILTS.

Telephone: *DEVIZES 536*

Graham Gear Co Ltd

SPURS
SPIRALS
BEVELS
8-100 D.P.

STATION ROAD
BROOKMANS PARK, HERTS.
Tel:- HATFIELD 3130



Specialists in
INSTRUMENT PRESSINGS

At The Hampton Works we prove that there are unlimited possibilities with presswork—especially in the production of small parts for the Electronic and Electrical Industries. Our claim as master craftsmen in pressings is your assurance of complete satisfaction. Every order is handled with extreme care and given prompt attention. We welcome your enquiry.

The HAMPTON WORKS
(STAMPINGS) LIMITED
PRESSWORK EXPERTS
TWYNING ROAD, STIRCHLEY, BIRMINGHAM, ENGLAND
Tel: KINgs Norton 2901 (3 lines) Grams Radiagills, B'ham

OVER 25 YEARS EXPERIENCE

Thermo-Setting Plastic Mouldings

Those " bits and pieces " that go into the complete assembly make all the difference to the efficient working of the final product.

As manufacturers of small components in the field of electronics, we have had long experience in producing THERMO SETTING PLASTIC MOULDINGS with accuracy and precision.

Your enquiries will receive our prompt attention.

HARRISON BROS
PLASTICS LIMITED
39-43, BRANSTON ST BIRMINGHAM 18

Telephone: COLmore 4270
Telegrams: " ARISUN, Phone, B'ham "

Switch on to

HENLEY SOLON
TRADE MARK
ELECTRIC SOLDERING IRONS

Solons save time, reduce costs. Solon soldering is always clean, reliable, and simple. Five models, in voltage range 100–250, each with 6 feet Henley flexible. 65 watt—oval tapered or round pencil bits. 125 watt—oval tapered or round pencil bits. 240 watt—oval tapered bit.

Write for Folder Y.10

W.T. HENLEY'S TELEGRAPH WORKS CO. LTD.
51-53 HATTON GARDEN, LONDON, E.C.1.

INSTRUMENT CASES

Size 8" x 7⅜" x 4¾"
Aluminium . . 25/-
Steel 20/-
Post & packing 1/6d. extra
Available in sizes to 12" x 12" x 4¾"
Various finishes

Send for List

SUTTON COLDFIELD ELECTRICAL ENGINEERS
Clifton St., Sutton Coldfield, Birmingham. Phone: SUT 5666

TRANSFORMERS
CHOKES
SOLENOIDS
COILS

- MADE TO YOUR SPECIFICATION IN ANY QUANTITY AT COMPETITIVE PRICES
- HIGHEST GRADE MATERIALS AND INSULATIONS USED
- DIE CAST FRAMES OR MOUNTING BRACKETS MADE FOR ALL FITTINGS

Send your enquiries to –

W.L.R.S. LTD.
DELTA HOUSE, 30 FAUCONBERG RD., CHISWICK, W.4
CHIS. 0384

WILKINSONS

C.W.2415/150

*ULTRA LOW
capacitance & attenuation

38 STOCK TYPES
for your
STANDARD or SPECIAL APPLICATIONS

TYPE	μμF/ft	IMPED.Ω	O.D.
C 1	7.3	150	.36
C 11	6.3	173	.36
C 2	6.3	171	.44
C 22	5.5	184	.44
C 3	5.4	197	.64
C 33	4.8	220	.64
C 4	4.6	229	1.03
C 44	4.1	252	1.03

TRANS T RADIO
U.G. CONNECTORS–R.G. CABLES
TRANSRADIO LTD. 138A Cromwell Rd. London SW7. *Tel: FRE.4421*

L. WILKINSON WHOLESALE AND EXPORT
19, LANSDOWNE ROAD, CROYDON
Phone : CRO 0839 *Telegrams :* "WILCO" CROYDON

RELAYS, P.O. TYPE 3000 AND 600
BUILT TO YOUR SPECIFICATION AT KEEN PRICES—QUICK DELIVERY—QUOTATION BY RETURN

WE ALSO HOLD CONSIDERABLE STOCKS OF

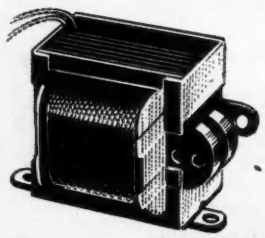
High Speed Relays.	Rectifiers Selenium.
Key Switches.	Jack Sockets & Plugs.
Uniselector Switches.	Meters.
Aerial Change Over.	Resistors High Stability.

ELECTRO-MAGNETIC COUNTERS
AS USED BY THE G.P.O. COUNTING UP TO 9999

TYPE 11A.	3 ohms 2/6 Vt. D.C.	12/6 each post 1/-
TYPE 17A.	3 ohms 2/6 Vt. D.C.	15/- " " "
TYPE 9G.	500 ohms 24/50Vt. D.C.	15/- " " "

STOCK LISTS AVAILABLE

A. C. SOLENOID TYPE SC.



Continuous 3 ozs. at ½"
Instantaneous to 39 ozs.
100% PRODUCTION INSPECTION
Larger Sizes Available
Also Transformers to 6 KVA 3 Phase.

R. A. WEBBER LTD.
18 FOREST ROAD, KINGSWOOD, BRISTOL. Phone : 74065

AIR COOLING

for

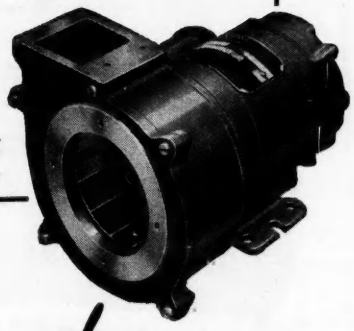
ELECTRONIC EQUIPMENT

★

VALVES

★

MERCURY ARC RECTIFIERS, etc.



Secomak REGD Electric BLOWERS

Send us particulars of your requirements.

"Secomak" Blowers are designed specifically for continuous use and complete reliability. Units with capacities up to 140 c.f.m. are available. They are suitable for a wide variety of cooling applications in electronic equipment.

SERVICE ELECTRIC CO. LTD.,

SECOMAK WORKS, HONEYPOT LANE, STANMORE, MIDDX.

Telephone : EDGware 5566-7-8-9.

SHORT BROTHERS & HARLAND

have vacancies in their Research Department for the following additional staff to work on guided missiles and other interesting military and commercial projects.

Mechanical Section : One Senior Engineer to develop hydraulic and pneumatic servos, precision mechanical devices, etc.

Electronics Section : One Senior Engineer to control various groups engaged on computing, navigational and servos systems.

Qualifications.—Honours Degree with at least five years good engineering development experience in appropriate field.

These are permanent positions in an expanding organisation.

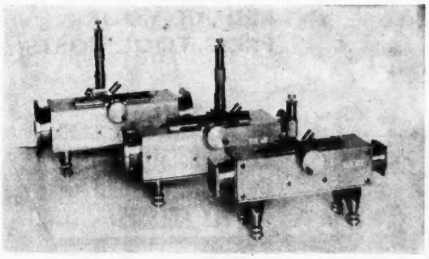
Good salaries and prospects for men with initiative ; pension scheme ; assistance with housing.

Send full particulars of age, qualifications and experience, with salary required, to

Short Brothers & Harland Ltd.,

Castlereagh Factory, Belfast,

quoting Ref. No. E7.



"THE AUTOMATIC WAY"

of VSWR measurements uses our high-precision standing wave indicators and indicating amplifier. The VSWR is read directly on the meter. For the highest accuracy and when phase values are taken the motor is stopped for a moment for ordinary manual operation. The cost of the motor attachment and of the extra circuits in the amplifier is low. The method saves more than 90 % of the time.

Figure out how much more work can be performed!

FREQUENCY METERS

Also direct reading frequency meters with unequalled flexibility. Four types cover frequency bands of 1 to 1.5 from 2,500 to 12, 400 Mc/s, direct reading in each band to 0.1 % or better. In the two low frequency bands they can be supplied with both coaxial and wave-guide connectors and with crystal mount, interchangeable at will. Accurate remote indication on linear counters or chart recorders is easily arranged. Build-in models available. All flange types supplied.

WRITE FOR CATALOGUE

SIVERS LAB HÄGERSTEN STOCKHOLM SWEDEN

NOW *The solution to your problem*

STURDY

***Transductors**

for fingertip control of POWER to 100 kVA

★ Transductors provide an ideal means of controlling A.C. power over a wide range. They possess the following advantages :

1. High efficiency
2. Low ratio of controlling power to load current
3. Maintenance cost negligible
4. Smooth and continuous variation from minimum to maximum
5. Remote control if required
6. Easily adaptable to automatic control

TRANSDUCTORS ARE IDEALLY SUITABLE FOR THE CURRENT CONTROL OF FURNACES—ELECTRO PLATING BATHS—DIMMING OF LIGHTS—AND MANY SIMILAR APPLICATIONS. DESIGNED TO SUIT INDIVIDUAL REQUIREMENTS.

Enquiries to :

Sturdy ELECTRIC COMPANY LIMITED

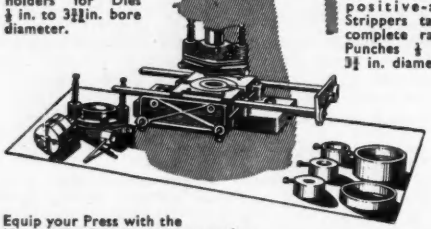
BURNOPFIELD, NEWCASTLE UPON TYNE Phone: Burnopfield 237

REDUCE YOUR PRESS TOOL COSTS

THE HUNTON UNIVERSAL BOLSTER OUTFIT FOR SHEET METAL PIERCING AND BLANKING ON FLY PRESSES

Bolster Frame with 2 adjustable gauges and insertable steel holders for Dies ½ in. to 3 31/32 in. bore diameter.

Two Punch Holders with detachable positive-action Strippers take the complete range of Punches ½ in. to 3¼ in. diameter.



Equip your Press with the Hunton Outfit and use **inexpensive standardised Punches and Dies ½ in. to 3¼ in. diameter obtainable from stock—in 1/16 in. sizes**—when you need them. Standardised Tools also available at short notice for Square, Oblong and other shapes, Louvre Forming (up to 8 in. long), Corner Notching, Corner Radiusing, Angle Iron Notching and Piercing, etc.

Get the outfit now—Buy Punches, Dies and tools as you need them.

Descriptive brochure and prices on request.

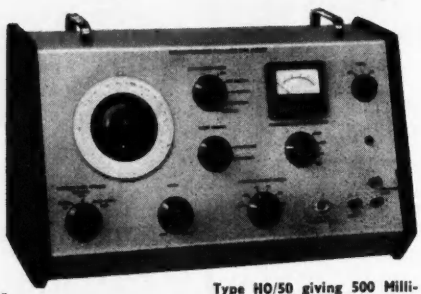
HUNTON LIMITED

Phoenix Works, 114-116, Euston Road, London, N.W.1.

Telephone: Euston 1477 *Telegrams:* Untonexh, London

INSIST ON HIFI *plus*

for Precision Instruments



Hifi REG'D TRADE MARK

Type HO/50 giving 500 Milliwatts output

Type HO/500 giving 5 watt output

+ Scale Calibration Accuracy of 1%.
+ Supplied in 3 Standard Frequency Ranges.
+ Output Voltmeter Fitted.
+ Built-in Attenuator.
+ High and Low Impedance Output.

Look for the Registered Trade Mark

Hifi Ltd. DERRY ST., BRIERLEY HILL, STAFFS. Telephone: Brierley Hill 7604

VARIACS for S-M-O-O-T-H Voltage Control

The "VARIAC"† is the original, continuously adjustable auto-transformer... the ideal control for varying the a-c voltage applied to any electrical, electronic, radar or communications equipment.

Voltages from Zero to 17% above line are obtained by a 320-degree rotation of the shaft, which is equipped with a direct-reading dial, calibrated accurately.

"VARIAC" offers many real advantages over any other type of a-c control: compared with the losses of resistive controls they save their initial cost within about one year. They are available in various sizes from 170 VA up to 25 Kilowatts. 3-gang assemblies are also available for 3-phase working. Prices vary from £7.10.0. upwards.

Write for our Catalogue—Technical Manual V-549, which gives all possible information, to:

CLAUDE LYONS LTD.

180 182 TOTTENHAM COURT ROAD, LONDON, W.1.
OR: 76 OLDHALL STREET, LIVERPOOL, 3, LANCASHIRE.

† Registered Trade Mark

Electronic Engineers

who are qualified and experienced are invited to apply to:

MARCONI'S WIRELESS TELEGRAPH CO. LTD.

for positions connected with expanding activities in the following fields:

MicroWave

wide band telecommunication systems

Airborne

communication and navigational aid equipment

Centimetric Radar

transmitters, receivers and associated equipment

Permanent and pensionable positions, some of senior status. Write quoting Ref. S.A. 49 to Dept. C.P.S., Marconi House, 336/7, Strand, W.C.2.

NORTHAMPTON POLYTECHNIC
St. John Street, London, E.C.1.

VACUUM TECHNOLOGY SUMMER SCHOOL

An intensive course (lectures and practical work) on vacuum technology will be conducted from September 13th to September 24th. It is intended for workers in industrial firms and research organizations, Government laboratories, etc. Applicants should have a general knowledge of physics of approximately degree standard.

Further particulars may be obtained from the Head of the Physics Department at the Polytechnic.

PROGRESS . . .

The result of splendid effort !

P.V.C. AND POLYTHENE SLEEVINGS INSULATED WIRES AND FLEXIBLES

British enterprise, energy and ingenuity produced the Jet Engine . . . There is no limit to British achievements . . . There is also no end to the Insulating Sleevings which we produce for many Industrial applications.

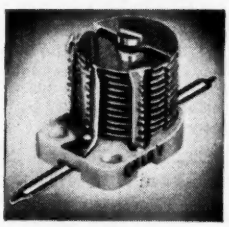
A.I.D. Approved.

PLASTICABLE LIMITED
Hawley Lane · Farnborough · Hants.
Phone : Farnborough Hants 85.

Excellence in design . .

Specialists in Subminiature Telecommunication Components

AIR DIELECTRIC TRIMMERS
70pF
Illustration (approx.) actual size



OXLEY

Type approved Cat.A No. 464
12 Vane type, 500 Volts
Width 16·5mm.
Length 22mm.
Height 19mm.
Insulation 10,000 megs.
Power Factor less than ·001
Temp. Coeff.:
50 parts/million/°C.

DEVELOPMENTS CO. LTD.
ULVERSTON, NORTH LANCS.
Tel. ULVERSTON 3306.

However involved—it's solved in a moment!

. . . whatever the problem, you can work out the answer —and it's at your finger-tips there and then . . . no wasted time waiting for departmental assistance. CURTA is the handiest calculating machine now on the market. It is precision built for absolute accuracy—it adds, subtracts, multiplies, divides, and is ideal for Scientists, Technicians and all Professional men.

Model 1 Capacity 8×6×11 £35 . . 10 . 0
Model 2 Capacity 11×8×15 £45 . 0 . 0

Provided with tens transmission and visible dials throughout, together with a handy reversing lever and split clearance of the product register. Write or phone today for a demonstration.

CURTA

LOM
LONDON OFFICE MACHINES LTD

LONDON OFFICE MACHINES LIMITED
Dept. E.E., Terminal House, Grosvenor Gardens, London, S.W.1. *Tele* : Sloane 1061, 1626, 3268, 3274
Branch Office : Lombard House, Great Charles Street, Birmingham 3 Tel : Central 1210 Branches also at Glasgow, Manchester, Sheffield, Nottingham. Dublin.

INSULATION

Our products include—
Presspahn and Leatheroid ; Pressboard ; Vulcanized Fibre ; Cable and Red Rope Paper ; Bakelite and Ebonite ; Varnished Paper and Tapes ; Varnished Silks and Tapes ; Varnished Glass and Tapes ; Varnished Cambric, Silk, Glass and P.V.C. Sleevings ; Cotton Tapes, Webbings and Sleeving ; Chatterton Compound ; Adhesive and Rubber Tapes.

PRESSPAHN, LTD.
Bradford, Yorks, England
Established 1900

REGISTERED ELECTRICAL WELLSTEAD INSULATION TRADE MARK

Telephone:
Bradford 25135 (Pvt. Br. Ex.)
Telegrams & Cables:
"Presspahn, Bradford"

'Radiospares' Quality Parts

The Service Engineer's First Choice

Electronic Engineers are changing to the ***Newtec***

'MINIMOUNT'

COMPONENT MOUNTING SYSTEM

(Brit. Pat. Appl. for)

because . . . . . .

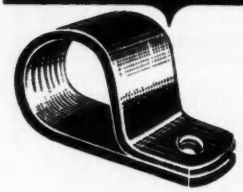
★ *it is so simple*
★ *it is so versatile*
★ *it reduces stock problems*
★ *it gives better joints more quickly*
★ *it simplifies identification*
★ *it is best for development*
★ *it is best for mass production*
★ *it is so inexpensive*

ASK FOR LEAFLET 52/9A FROM

JOYCE, LOEBL & Co. LTD.

Vine Lane, NEWCASTLE-upon-TYNE, 1.

PLASKLIP *NON-METALLIC CLIPS*



Provide the means for the correct securing of components and cable looms in radio and electrical instruments and equipment. The very extensive range covers wiring requirements generally. Made in high dielectric material, non-electrolytic, non-magnetic, radiused edges, fully tropical. Approved all services.

Samples and literature on request

INSULOID MANUFACTURING COMPANY LIMITED

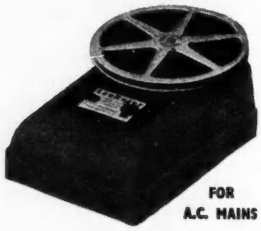
Sharston Works, Leestone Ave., Wythenshawe, Manchester. Tel: Wythenshawe 2842

LEEVERS RICH

For clean, noise-free Recordings—the

Lee Raser

Tape De-magnetiser—as supplied to B.B.C. and leading recording studios.



FOR A.C. MAINS

MODEL B (up to 7" spool capacity) **£9.10.0.**
MODEL C (up to 12" spool capacity) **£15.0.0.**
Tropical Specification

LEEVERS-RICH EQUIPMENT LTD.

Manufacturers of high quality magnetic recorders

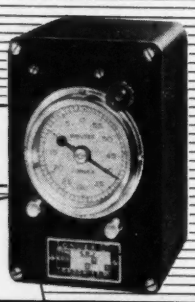
37, WARDOUR STREET, LONDON, W.1. GER. 4502.

LONDEX

TRADE MARK

PROCESS TIMERS

WRITE FOR LIST PT/EE



LONDEX LTD ANERLEY WORKS LONDON, S E 20

TECHNICAL BOOKS

H. K. LEWIS & Co. Ltd. invite inspection of their stock of books on all branches of Radio and Electrical Engineering. Catalogue on request.

LENDING LIBRARY: Technical and Scientific. Annual Subscription from TWENTY-FIVE SHILLINGS

Prospectus Post Free on Request.

THE LIBRARY CATALOGUE revised to December, 1949, containing a classified Index of Authors and Subjects. To subscribers, 17s. 6d. net. To non-subscribers, 35s. net. Postage 1s. 3d. Supplement 1950-52. To subscribers, 3s. net. To non-subscribers, 6s. net, postage 6d.

LONDON: H. K. LEWIS & Co. Ltd., 136 Gower St., W.C.1

Telephone: EUSton 4282 (7 lines)

TYPE APPROVED VITREOUS WIRE WOUND RESISTORS — QUICK DELIVERY LOW PRICE

Labgear (Cambridge) Limited

WILLOW PLACE, CAMBRIDGE, ENGLAND

Telephone: CAMBRIDGE 2494 (2 lines) Telegraphic Address: "LABGEAR, CAMBRIDGE"

PATENT EXPLOITATION

For the exploitation of patents on its interesting invention in the Electrical Engineering field, Dutch Company wishes to contact **PATENT EXPLOITATION AGENT** or **ENGINEERING FIRM** of repute, maintaining good relations with British Industrial circles.

Letters to be addressed under Nr. SS To :

RECLATECHNICA, Advertising Agency, Singel 521, Amsterdam, HOLLAND.

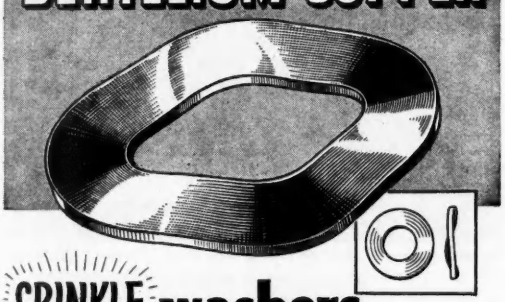
We Specialise in . . .

MAGSLIPS SELSYNS
and other
ROTATING COMPONENTS
for
AUTOMATIC CONTROL SYSTEMS

Brochure available from :—

Servo and Electronic Sales Ltd.
1, HOPTON PARADE, STREATHAM HIGH ROAD, LONDON, S.W.16
STReatham 6165

BERYLLIUM COPPER



CRINKLE washers

Heat treated and plated, giving corrosion resistance with high degree of recovery in relation to load, and resistance to "set". Spring locking action suitable for electronic and instrument components. Size range ½" to 8 B.A.

Prices and samples sent on request.

CONTRACTORS TO THE ADMIRALTY • MINISTRY OF SUPPLY • & OTHER GOVERNMENT DEPTS.
DAVID POWIS & SONS LTD
FORWARD WORKS SPARKBROOK BIRMINGHAM 11 PHONE VIC 1264-8

An Important Service to Industry and Research . . .

The Design and Manufacture of

PNEUMATIC
HYDRAULIC and
ELECTRONIC
CUSTOM MADE EQUIPMENT

Examples of work in progress :

A wide range of stabilized power supply units.
Oscillators 0·01 c/s - 10 Mc/s using 6ft. scales.
A wide range of wave-form generators, A.C., D.C. and Video Valve Voltmeters using 12 inch scales.
Servo-operated recorders using 10, 25 and 50 cm. scales.
Type 0 and Type 1 Servo Drives.
Millimicrosecond Pulse Equipment. Microphotometers. Stroboscopes.

The Symbol of Service . . .

L.M.B. INSTRUMENTS LTD.
OLD BEDFORD ROAD, LUTON, BEDS. Phone : Luton 4336

"SPEARETTE"

MINIATURE VALVE PIN ALIGNING TOOLS

TYPES AVAILABLE FOR
B7G - B8A - B9A - B9G
VALVE BASES
BENCH AND CHASSIS MOUNTING

SPEAR ENGINEERING CO. LTD.
WARLINGHAM · SURREY
Telephone : Upper Warlingham 2774

SPECIALISTS IN PACKING ELECTRONIC EQUIPMENT

SYNTHETIC SUPPLIES LTD.

ALBERT MILLS · SILK STREET
ECCLES · MANCHESTER
Telephones : ECCles 1720 & 3225/6

Casemakers and general joinery : Packing and Preservation : Shipping and Forwarding Agents: Warehousing

Contractors to the Admiralty, Air Ministry, Ministry of Supply & G.P.O. Approval No. B23789/40

INDUSTRIAL PROBLEMS

Why wait for delivery of Essential Electronic Instruments?

We can supply your needs AT ONCE from our VERY LARGE Stocks of the following manufacturers instruments :

Advance **Electronic Instruments**
Avo **Taylor**
Cossor **Telequipment**
Dawe **Waveforms**

For immediate delivery, consult :—

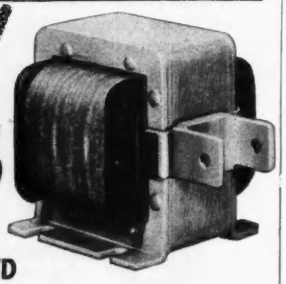
A. C. FARNELL LTD., 15 Park Place, Leeds, 1.

Telephone : Leeds 32958/9.

(Official Agents for Advance, Avo, Cossor, Dawe, Waveforms, Taylor and Telequipment).

HILTON RELAYS HILTON RELAYS HILTON RELAYS

HILTON SOLENOIDS



HILTON ELECTRIC CO. LTD

52 POOL ST. WOLVERHAMPTON *Phone: 22783*

HILTON RELAYS HILTON RELAYS HILTON RELAYS

RESISTANCE WIRES

TOPHET

STAINLESS STEEL WIRES

The 'Tophet' range of resistance materials is eminently suitable for use under the most exacting conditions as the physical and mechanical properties always remain constant, ensuring long and efficient service.

Our RESISTANCE HANDBOOK gives complete electrical and physical data regarding 'Tophet' resistance wires, stainless steels and ultra fine wire, as well as particulars of our 'Truflex' thermostatic bimetal.

Manufactured by **GILBY-BRUNTON LIMITED**

HEAD OFFICE & WORKS: SEAMILL, MUSSELBURGH, SCOTLAND
Telephone : Musselburgh 2369

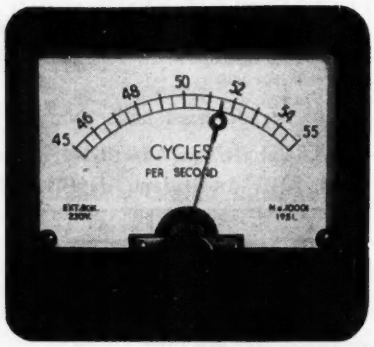
LONDON OFFICE: 47 WHITEHALL, S.W.1. *Tel : WHitehall 6058*

FREQUENCY METERS

SIZES : 2½" to 8"

UP TO 5000 CYCLES

PROMPT DELIVERY



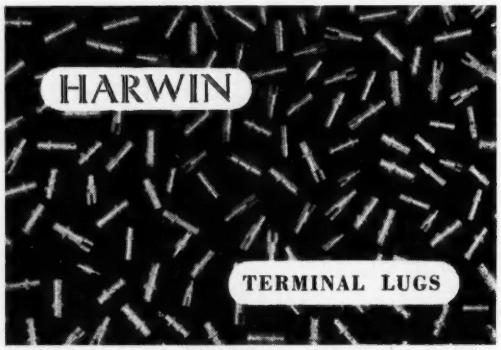
also the new **SYNCHROSCOPE**
M.C. KILOVOLTMETERS
and full range of Switchboard Instruments.

Ask for illustrated Catalogue

THE ELECTRICAL INSTRUMENT CO. (Hillington) LTD.

HILLINGTON, GLASGOW

London stockists, H. A. Patterson, 156 High Holborn.



Harwin Engineers Ltd., 101 Nibthwaite Road, Harrow, Middlesex

A.I.D. APPROVED

VALVE RETAINERS FOR ALL VALVES

HART BRITISH

COIL WINDERS TO M.O.S.

H. COLLARD HART LTD.

Specialists in the manufacture of coils, H.F. & I.F. chokes, etc., and small electronic and electrical components to customers specification.

WEST CRAVEN STREET, SALFORD 5.

WE'VE A WAY WITH KNOTTY PROBLEMS!

The tougher your cable problems, the more we like them. We're experts at designing and producing special purpose cables.

We can also, of course, produce P.V.C. insulated DURACABLE to your own specification and we stock most standard types of P.V.C., Polythene and * DURATHENE insulated wires and cables. Perhaps we can help *you*; why not get in touch with us?

** DURATHENE is our method of making the best of both worlds. It combines the very high dielectric strength of Polythene with the tremendous toughness of P.V.C. Total weight of insulation is less with no loss of safety. It means lighter, more flexible wiring which is easier to handle, move, store and install. And DURATHENE has all these advantages at a competitive price.*

DURATUBE & WIRE LTD.

FELTHAM · MIDDLESEX · ENGLAND

DRAYTON

FRACTIONAL H.P. MOTOR UNITS

The DRAYTON R.Q. is a miniature capacitor induction type motor with a current consumption at 230 volts, 50 cycles of 0.09 amps pf. 0.9. It is available:

RQG GEARLESS
Running at 2,700 r.p.m. continuously or intermittently in either direction or continuously reversed.

RQR GEARED
For continuous or intermittent running or reversing at speeds from 27 mins. per rev. to 600 revs. per min., with or without self-switching up to 2 1/3 r.p.m.

RQH GEARED
For high final shaft speeds for continuous or intermittent running, forward or reverse.

for

actuating valves, dampers, rheostats, geneva movements, rocking baths, flashing signs, illuminated models, soldering and welding fixtures, rotating tables, automatic light strip feed, lubricating and other small pumps, small machines, animated displays, vibrators, developing baths, agitators, fans, aspirators, etc.

Send for List No. M. 302-1 RQ19

The Drayton Regulator & Instrument Co. Ltd., West Drayton, Middlesex

Introducing.... packing and preservation 'On Site'

A NEW regular feature of **E.P.S SERVICE**

Whenever speed, size, convenience or security suggest that packing *on site* is preferable to transporting products to an E.P.S. Centre for scientific packing and preservation, this new mobile service will bring the full resources of a complete packing design and production organisation to *you*. Specially selected, trained and equipped teams of experts are now available for packing and preservation 'on site' anywhere, and they will work independently or as part of your organisation, according to need.
This 'on site' service lends itself particularly successfully to work involving PLASTIC SPRAY COATING. If you have a problem to which 'on site' service might apply, we shall be glad to discuss it with you.

EXPORT PACKING SERVICE LTD.
Imperial Bldgs., 56 Kingsway, London, W.C.2.
Telephone: CHAncery 5121/2/3
and at:
CARDIFF · BANBURY · MERTHYR · SITTINGBOURNE

PACKED BY EPS EXPORT PACKING SERVICE LTD

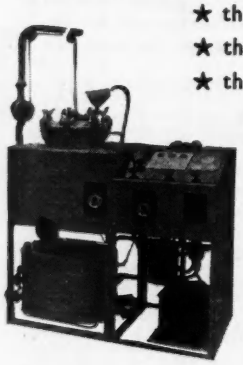
GIVE YOUR WINDINGS A GOOD LIFE

impregnate with a

BLICKVAC HIGH-VACUUM IMPREGNATOR

Full range of models available to meet the needs of

★ the large-scale Producer
★ the Research Laboratory
★ the small Rewind Shop



BLICKVAC UNITS MEET THE MOST STRINGENT SPECIFICATIONS.

Outstanding Features :

- Ease in control
- Simple attachment of auxiliary autoclaves
- Fully demountable to facilitate cleaning
- Best quality fittings throughout
- Unequalled flexibility and performance
- Units available suitable for:

VARNISH, WAX, BITUMEN, POTTING RESINS

If your problem is **Coil Impregnation**
CONSULT BLICKVAC

Write today to Hamilton Road Works, Hamilton Road, S.E.27
GIPsy Hill 4394

Associated with Blick Time Recorders Ltd., Blick Engineering Ltd.

A. BORLAND LTD.
ENGINEERS

TURNED PARTS IN FERROUS OR NON-FERROUS MATERIALS TO CLOSE LIMITS. CAPACITY FOR SPEEDY DELIVERY UP TO 2¼"

Your enquiries invited

39/40 SUMMER HILL ROAD, BIRMINGHAM, 1

"SANOID" FIRST AID

For over fifty years we have studied and supplied the specialised First Aid requirements of Industry. We believe our efforts have been of advantage to those we are privileged to serve, as on many occasions we have been able to meet the particular needs of various industries and conditions.

May we help you? Our wide experience is at your service, and we should be pleased to quote you for your specific requirements.

A PRODUCT OF
Cuxson Gerrard & Co. Ltd.
OLDBURY BIRMINGHAM

FIRST AID SPECIALISTS
ESTABLISHED 1878

WHETHER EASY OR DIFFICULT

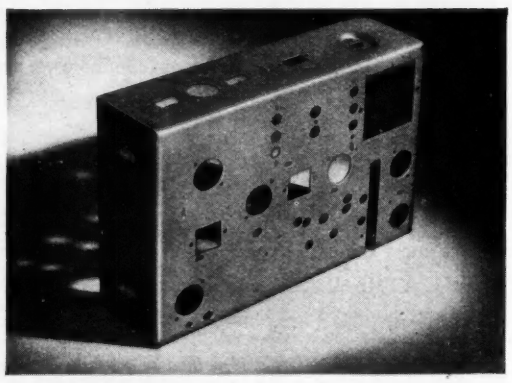
one or many, we can undertake

SHEET METAL CASES & LIGHT ENGINEERING

to the highest standards

CLEVELAND ART METAL WORKS

23 Mortimer Market, Tottenham Court Road, London, W.C.1. EUSton 4169.



PLASTIC MOULDERS

A.I.D. Approved

Phone High Wycombe 1921/2

COMPRESSION
TRANSFER
INJECTION

Over 50 PRESSES
MODERN TOOL ROOM

ELCO PLASTICS LTD. High Wycombe. Bucks.

CANNING High Speed **KADAMAX**
PLATING PROCESS

"CONFORMS TO MINISTRY OF SUPPLY SPEC." DTD 904

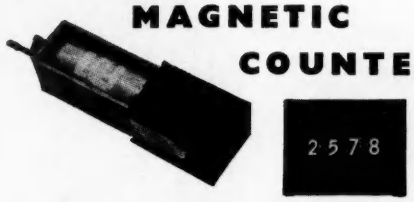
Ideal for the protection of radio chassis, switchgear, meter fittings, electrical components, aircraft parts and most iron and steel articles.

- SIMPLE AND RELIABLE PROCESS
- RUST PROOF FINISH
- EASY TO SOLDER
- BRIGHT ATTRACTIVE DEPOSIT

Existing cadmium solutions may be converted subject to satisfactory analytical test report.

W. CANNING & CO. LTD. BIRMINGHAM 18. LONDON & SHEFFIELD

ELECTRO-MAGNETIC COUNTER

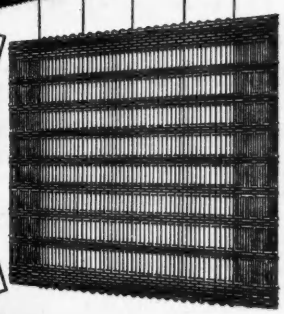


MAJOR TYPE 6 × 1½ × 1¼ ins.
FOUR FIGURES
TWO TYPES
3 ohms operates on 3/6 Vo. D.C.
500 ohms operates on 18/24 Vo. D.C.
17/6 Post & Pkg. 9d.

MAGNETIC RELAYS
UNISELECTORS
KEY SWITCHES

JACK DAVIS (RELAYS) LTD.
Dept 'E' 36 PERCY STREET, LONDON, W.1
MUSEUM 7960 LANGHAM 4821

LIGHT WEIGHT
RESISTANCE GRIDS and NETS
ASBESTOS WOVEN



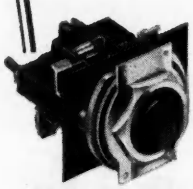
THE steadily increasing demand for CRESSALL Asbestos Woven Resistance Grids and Nets is proof of their pre-eminence in this type of resistance unit. The nets are light in weight, rigid, and vibration and shockproof, and are made from the most carefully selected materials. We offer a range of standard sizes to meet almost any requirement for a single resistance unit or a banked assembly. Illustrated catalogue can be supplied on request.

CRESSALL

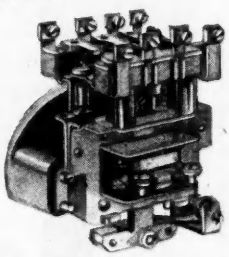
Registered trade name of
THE CRESSALL MANUFACTURING CO. LTD
TOWER STREET · BIRMINGHAM 19

DONOVAN ACCESSORIES— FOR THE ELECTRONIC APPARATUS MANUFACTURER!

TYPE J.96 TERMINAL BLOCKS. Made in 15, 30 and 60 amp. sizes.



Type C.30 PUSH-BUTTON UNIT arranged for mounting on customers' own cover plate.

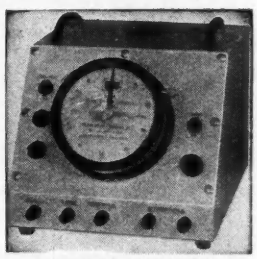


Type A.11 A.C. POWER RELAY – 4-pole with N.O. or N.C. contacts.

THE DONOVAN ELECTRICAL CO. LTD.
Safuse Works · Stechford · Birmingham 33

EQUIPMENT FOR
RESEARCH
AND
DEVELOPMENT

- ★ **Vibration Equipment**
- ★ **High Speed Electric Counters**
- ★ **Strain Gauge Equipment**
- ★ **High Accuracy Tachometers**
- ★ **Temperature Measuring Equipment**



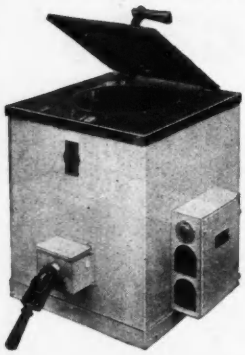
NEOSTRON COUNTING UNIT
Valve-triggered counting unit, incorporating D.W.A. High-Speed Pulse Register, for accurate timing applications where the instrument counts tuning fork oscillations, or any other rotary or oscillating motions using photo-electric or other pick-ups.

DAVIS, WYNN & ANDREWS LTD
SCIENTIFIC EQUIPMENT
DWA
CHELTENHAM ENGLAND
TELEPHONE 53606 TELEGRAMS "INVENTION"
E/DWA. .I

Designed for

HARD-TO-HEAT COMPOUNDS

This ' B-W ' Standard auto controlled Electric Kettle is just one example from our wide range of industrial heating equipment. These kettles are fitted with a heated outlet valve and are supplied in many sizes with or without stirring gear. Heated pots and tanks of all types also available. Write for details today.



★

'B-W'

***Electric* INDUSTRIAL KETTLES**

ALL MODELS FITTED WITH **AUTO-CONTROL**

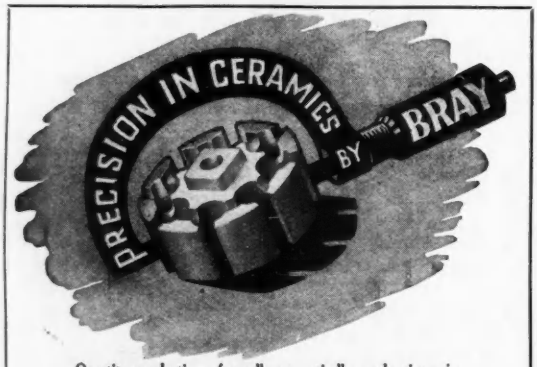
'B-W' STANDARD PRODUCTS INCLUDE:

★ FURNACES ★ OVENS
★ GLUE HEATERS ★ WAX TANKS
★ DIP POTS ★ HUMIDITY CABINETS

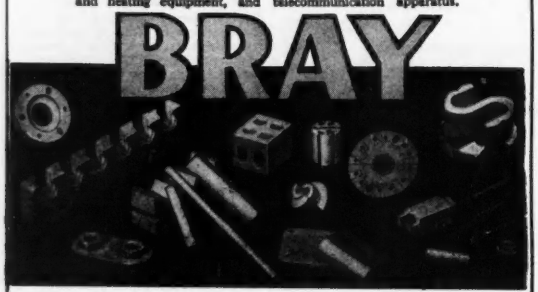
INDUSTRY NEEDS HEAT — YOU NEED 'B-W'

Barlow-Whitney

All enquiries to :
SALES OFFICE : **2 DORSET SQ., LONDON, N.W.1. AMBassador 5485**
WORKS : **NEASDEN & BLETCHLEY.**

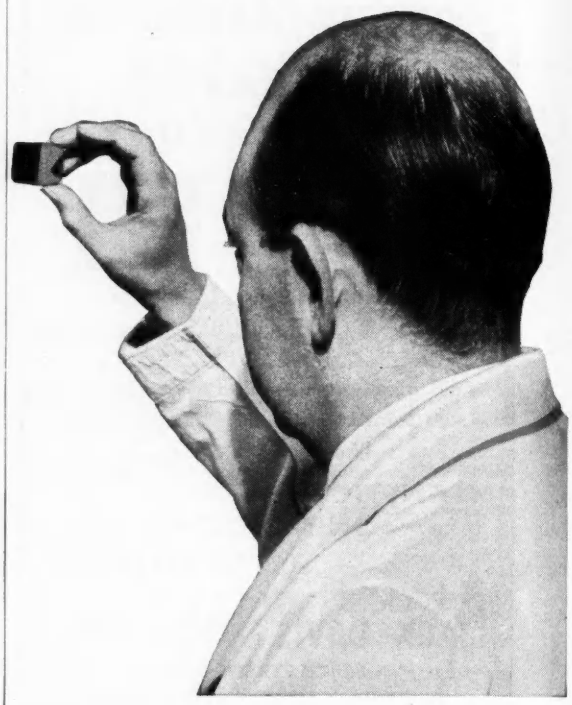


Quantity production of small automatically made pieces in Steatite, Porcelain, and Rutile materials for electric cooking and heating equipment, and telecommunication apparatus.



GEO. BRAY & CO. LTD., Leicester Place, Leeds 2.
Tel. : 20981/9. Grams. : "Bray, Leeds"

BOSTIK'S PART IN...



GUARDING AGAINST GAMMA RAYS...

The problem was to manufacture cassettes to hold a special monitoring film, so that half the film would be exposed direct through perspex and the other half masked by lead. It was not practicable to join the perspex and lead with mechanical fastening and not possible to join them with the usual industrial adhesives. So a special "Bostik" adhesive was produced by our chemists. In providing a perfect bond, it offered complete protection to the operator wearer, since at no time could the lead and perspex come apart thus exposing him to the dangers of excess gamma radiation. You, too, may have a problem that can be solved by our chemists because this example is

ONLY ONE OF THE WAYS IN WHICH

Bostik

ADHESIVES AND SEALING COMPOUNDS

can serve the Electrical Industry

'BOSTIK' is the registered trademark of the sole manufacturers:
B. B. CHEMICAL CO. LTD., ULVERSCROFT ROAD, LEICESTER

THOS. ALLNUTT & CO.

Metal Thread and Wood Screws Turned or Pressed Nuts, Plain, Shakeproof and Spring Washers for all purposes. Wing Nuts.

SOLDERING TAGS AND EYELETS

LEE CHAPEL LANE
LANGDON HILLS, Essex

Telephone: LAINDON 122
Home & Export

PURE SWEDISH CHARCOAL SOFT MAGNETIC IRON FOR ALL ELECTRO-MAGNETIC APPLICATIONS

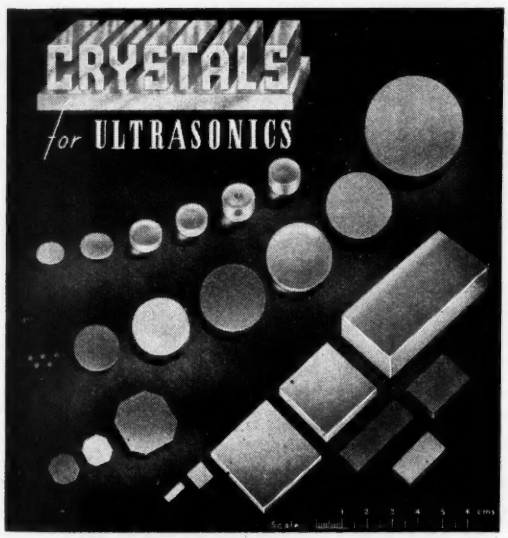
Deep-drawing and Standard Qualities in Bars, Rods, Strips, Wire, Forgings, etc.

PROMPT DELIVERY

Full details and data from :

ERNST B. WESTMAN LIMITED,
39 Lombard Street, London, E.C.3

'Phone : Mansion House 5831-5. *Cables : Jernagent, London*



Quartz Crystals of any shape and size cut and ground precisely to specification and coated, if required, with Gold, Silver, Aluminium or Rhodium, etc.

BROOKES

Brookes Crystals Ltd.,
Suppliers to Ministry of Supply, Home Office, B.B.C., etc.
EARLSWOOD ST., GREENWICH, LONDON, S.E.10
Telephone : GREenwich 1828
Grams: Xtals Green London. *Cables*: Xtals London

ELECTROPLATERS TO THE ELECTRONIC INDUSTRY

ATLAS are now well established as the premier Electro-Platers for the metal finishing of ELECTRONIC COMPONENTS. Our work is laboratory controlled resulting in a high standard of finish.

We are in a position to undertake large quantity production of silver plating on light alloy or other base materials,

●

Service is also available for Electro-forming of Wave Guides or intricate shaped components,

●

ATLAS
PLATING WORKS Ltd
Avenue Road, Acton, London, W.3.
Telephone: ACOrn 1102

If you need

a small **METAL PRESSING** for your product, why not consult us ?

We specialise in light precision presswork in all metals for the Electrical Trades

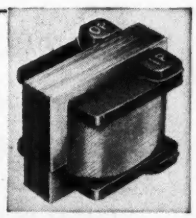
QUOTATIONS BY RETURN

BIRMINGHAM SPECIALITIES LTD.
80-81 BATH STREET · BIRMINGHAM 4
Phone: CENTRAL 2492

BELCLERE

MINIATURE

Standard Input
TRANSFORMER



Small, efficient, low priced, size 1" × ¾" × ¾" overall as illustrated. Uses : For coupling inputs of 3-150 ohms to normal type pentode valves. Specification : Ratio 1-50, Primary 3.5 ohms. Secondary inductance 160 H at 1,000 c.p.s. Range 6½ octaves ± 2 db. Finish varnish dip, encapsulated block or mu-metal screening can.

Quick delivery—low price—maximum efficiency.

JOHN BELL & CROYDEN, 117 HIGH STREET, OXFORD
Telephone : 47072 ● Cables : Belclere, Oxford

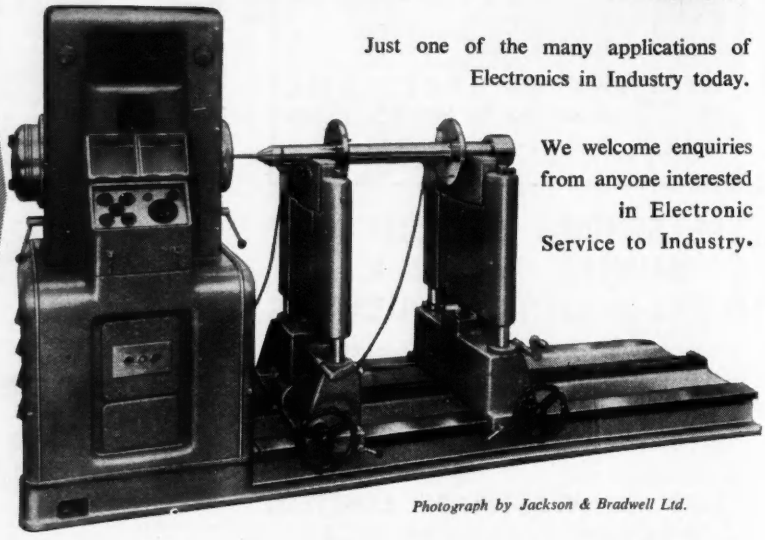
THE DYNAMIC BALANCING MACHINE

WITH ELECTRONIC EQUIPMENT BY EVANS

DEVELOPED by

EVANS ELECTRONIC DEVELOPMENTS LIMITED

EVONIC HOUSE,
BIRCHFIELD ROAD,
BIRMINGHAM 19.



Photograph by Jackson & Bradwell Ltd.

Just one of the many applications of Electronics in Industry today.

We welcome enquiries from anyone interested in Electronic Service to Industry.

LUMINESCENT MATERIALS

FOR

ELECTRIC DISCHARGE LAMPS
CATHODE RAY TUBES
X-RAY SCREENS
INSTRUMENT DIALS
DECORATIVE DISPLAYS

SPECIAL PHOSPHORS MADE TO CUSTOMERS' SPECIFICATIONS

★ ★ ★

DERBY & COMPANY LTD.

Offices :
11-12 St. Swithin's Lane, London, E.C.4.

Telephone : MINCING LANE 5272.
Telegrams : PLATIVET, London.

Works :
Millmarsh Lane, Brimsdown, Middx. HOWard 2208

MILTOID LTD

STOCKISTS OF

BX POLYSTYRENE

A first-class rigid insulating material, supplied in sheets and rods in a range of thicknesses and diameters ex stock.

•

Information and guidance on manipulation, machining and cementing available on request.

MILTOID LTD.

34/36 Royal College Street, London, N.W.1.
'Phone : EUSton 6467. 'Grams : Celudol, Norwest, London

INDEX TO ADVERTISERS

A

Acheson Colloids Ltd. 69
Advance Components Ltd. .. 73 and 75
Aero Research Ltd. 15
Airmec Ltd. 74
A.K. Fans Ltd. 96
Alinutt & Co., Ltd., Theo. 115
All-Power Transformers Ltd. .. 64
Ashton, N. C. 78
Atlas Plating Works Ltd. 115
Austinlite Ltd. 60
Automatic Coil Winder & Equipment Co., Ltd., The 17

B

Baldwin Instrument Co., Ltd. 96 and 99
Barlow-Whitney Ltd. 114
Barrington Products Ltd. 97
B.B. Chemical Co. 114
Bell & Croyden, John 115
Belling & Lee Ltd. 65
Birmingham Specialities Ltd. .. 115
Blickvac Ltd. 112
Booth & Co., Ltd., James 66
Borland Ltd., A. 112
Bray & Co., Ltd., George 114
British Electrical Resistance Co., Ltd. 99
British Insulated Callender's Cables Ltd. 53
British Thomson-Houston Co., Ltd. 19
Brooke's Crystals Ltd. 115
Broxlea Products Ltd. 98
Bullers Ltd. 72

C

Canning Ltd., W. 112
Carron Parlanti Ltd. 98
Cementation Ltd. 61
Chance Bros. 95
Chapman & Hall Ltd. 327
Chase Products Ltd. 101
Cinema-Television Ltd. 63
Cleveland Art Metal Works 112
Cohen, Sons & Co., Ltd., George .. 101
Cole Ltd., E. K. 5
Collard Hart Ltd., H. 110
Cooper & Co. (Birmingham) Ltd. .. 101
Cossor Ltd., A. C. 62
Counting Instruments Ltd. 95
Cressall Manufacturing Co., Ltd., The 113
Cuxson, Gerrard & Co., Ltd. .. 112
Cygnet Joinery Ltd. 101

D

Davis (Relays) Ltd., Jack 113
Davis, Wynn & Andrews Ltd. .. 113
Dawe Instruments Ltd. 94
Derby & Co., Ltd. 116
Dobbie McInnes Ltd. 94
Donovan Electrical Co., Ltd. .. 113
Dowding & Doll Ltd. 31
Drayton Regulator & Instrument Co., Ltd. 111
Duratube & Wire Ltd. 111

E

Edison Swan Electric Co., Ltd. Cover ii, 25, 27 and 59
Elco Plastics Ltd. 112
Electrical Instrument Co., Ltd. .. 110
Electronic Engineering Monographs 327 and 100
Enthoven & Sons, Ltd., H. J. Cover iv
Ericsson Telephones Ltd. 93
Evans Electronic Developments Ltd. 116
Ever-Ready Co. (Great Britain) Ltd. 9
Evershed & Vignoles Ltd. 35
Export Packing Service Ltd. 111

F

Farnell Ltd., A. C. 110
Ferranti Ltd. 37
Firth-Vickers Stainless Steels Ltd. .. 93
Fox Ltd., P. X. 52

G

Gardner's Radio Ltd. 39
General Electric Co., Ltd., The .. 11
General Engineering Co. (Radcliffe) Ltd. 50
Gilby-Brunton Ltd. 110
Goodman's Industries Ltd. 49
Graham Gear Co., Ltd. 103
Gresham Transformers Ltd. 51

H

Haddon Transformers Ltd. 100
Hampton Works (Stampings) Ltd. .. 103
Harrison Bros. (Plastics) Ltd. .. 103
Harwin Engineers Ltd. 110
Hassett & Harper Ltd. 48
Honley's Telegraph Works Co., Ltd., W. T. 103
Hifi Ltd. 106
Hill Ltd., C. & L. 46
Hilton Electric Co. 110
Hivac Ltd. 44
Hunt Ltd., A. H. 14
Hunton Ltd. 106

I

Imhof Ltd., Alfred 78
Imperial Chemical Industries Ltd. .. 42
Insuloid Manufacturing Co., Ltd. .. 108
Isotope Developments Ltd. 84

(*continued on next page*)

CO-AX PRECISION CONNECTORS
Better ON *all* COUNTS

- design
- machining
- performance
- price
- delivery

The most comprehensive range of
U.S. CONNECTORS outside the U.S.A.

CO-AX Connectors
CO-AX Cables R.G. Cables
Microdual drives

TRANSRADIO LTD. 138A Cromwell Rd. London S.W.7. Tel: FRE4421

Counting by VEEDER-ROOT

COUNTERS FOR EVERY INDUSTRY

BACKED BY 70 YEARS EXPERIENCE

Please write for illustrated folder "EL" giving details of full range. Representative will call upon request.

Veeder-Root LTD. REGD. TRADE MARK
DUNDEE
Phone No. 85218
The Name that Counts!
London Office
20 PURLEY WAY, CROYDON, SURREY
Telephone THORNTON HEATH 3477-8

INDEX TO ADVERTISERS (*continued from previous page*)

J

Jackson Bros. 92
Joyce, Loebl & Co. Ltd. 108

L

Labgear (Cambridge) Ltd. 108
Lange, Maxwell & Springer Ltd. .. 326
Langham Thompson Ltd., J. 54 and 55
Leevers-Rich Equipment Ltd. .. 108
Lewis Ltd., H. K. 108
Lewis Spring Co., Ltd. 92
Lion Switchgear Ltd. 40
L.M.B. Instruments Ltd. 109
Londex Ltd. 108
London Electric Wire Co. & Smiths Ltd. 118
London Office Machines Ltd. .. 107
Lyons Ltd., Claude 106

M

Magnesium Elektron Ltd. 68
Magnetic & Electrical Alloys Ltd. .. 89
Magnetic Devices Ltd. 34
Marconi Instruments Ltd. 71
Marconi's Wireless Telegraph Co., Ltd. .. .. 23, 29, 47 and 106
Metachemical Processes Ltd. 43
Midland Silicones Ltd. 38
Miltoid Ltd. 116
Muirhead & Co., Ltd. 36
Mullard Ltd. .. .. .. 41 and 58
Murex Ltd. 91

N

Nagard Ltd. 32
Neill & Co. (Sheffield) Ltd., James .. 90
New Electronic Products Ltd. .. 91
Northampton Polytechnic 107

O

Oxley Developments Ltd. 107

P

P.A.R. Ltd. 67
Philips Electrical Ltd. 90
Plannair Ltd. 3
Plasticable Ltd. 107
Power Controls Ltd. 30
Powis & Sons Ltd., David 109
Precision Rubbers Ltd. 3
Precision Screw & Manufacturing Co., Ltd. 89
Pressphn Ltd. 107
Pye Ltd., W. G. 28

R

Radford Electronics Ltd. 77
Radiospares Ltd. 107
Ragosine Oil Co., Ltd. 67
Ratcliffe (Rochdale) Ltd., F. S. .. 57
Reclatechnica 109
Redifon Ltd. 77
Rivlin Instruments Ltd. 88
Rocke International Ltd. 97
Rola-Celestion Ltd. 88

S

Salford Electrical Instruments Ltd. 87
Salter & Co., Ltd., George 26
Sandwell Casting Co., Ltd. 87
Sanigiard Appliances Ltd. 86
Sankey & Sons Ltd., Joseph 86
Saunders-Roe Ltd. 24
Savage Ltd., W. Bryan 79
Savage Transformers Ltd. 84
Service Electric Co., Ltd. 105
Servo & Electronic Sales Ltd. .. 109
Servomex Controls Ltd. 13
Sheffield Smelting Co., Ltd. .. 79
Short Bros. & Harland Ltd. 105
Sivers Lab. 105
Solartron Laboratory Instruments Ltd. Cover i and 7
Southern Instruments Ltd. 22
Spear Engineering Co., Ltd. 109
Standard Telephones & Cables Ltd. 21, 33 and 76
Steatite & Porcelain Products Ltd. 20
Steatite Insulations Ltd. 56
Sturdy Electric Co., Ltd. 105
Sugg Ltd., William 85
Sullivan Ltd., H. W. 85
Superflexit Ltd. 45
Sutton Coldfield Electrical Engineers 104
Synthetic Supplies Ltd. 109

T

Telcon Magnetic Cores Ltd. 82
Telegraph Condenser Co., Ltd. Cover iii
Telegraph Construction & Maintenance Co., Ltd. 84
Telemechanics Ltd. 83
Telephone Manufacturing Co., Ltd. 83
Tetra Engineering Co., Ltd. 102
Transradio Ltd. .. .. 102 and 104
Trumeter Co., Ltd. 82
Truvox Engineering Co., Ltd. .. 81
Twentieth Century Electronics Ltd. 70

U

Unbrako Socket Screw Co., Ltd. .. 18
United Ebonite & Lorival Ltd. .. 16

V

Vacuum Industrial Applications Ltd. 80
Veeder-Root Ltd. 102
Vickers-Armstrongs Ltd. 81

W

Webber Ltd., R. A. 104
West London Rewind Service Ltd. .. 104
Westman Ltd., Ernst B. 115
Wilcox & Co., Ltd., Edward 80
Wilkinson, L. 104
Wilkinson's Tools Ltd. 104
Wolf Electric Tools Ltd. 102

BARE & INSULATED

RESISTANCE WIRES

THE LONDON ELECTRIC WIRE COMPANY AND SMITHS LIMITED — LEW — SMITHS

for INSULATED WIRES

VACTITE WIRE COMPANY LIMITED — VACTITE

for BARE WIRES

EUREKA & VACROM

EUREKA REGD. (CUPRO-NICKEL)

VACROM REGD. (NICKEL-CHROME)

'Eureka' (Regd.) and 'Vacrom' (Regd.) Resistance Wires can be supplied BARE or with STANDARD COVERINGS of cotton, silk, rayon, enamel and glass.

These wires have been used for many years for winding resistances for instruments, control apparatus, etc.

'Eureka' with its low temperature coefficient is always in demand for precision work, while Nickel-Chromes are used where a high resistance is required in a limited space.

Full details gladly supplied upon request

THE LONDON ELECTRIC WIRE COMPANY AND SMITHS, LIMITED
LEYTON, LONDON, E.10.

VACTITE WIRE COMPANY LTD.
75 ST. SIMON STREET,
SALFORD 3, LANCS.

Printed in Great Britain by The Press at Coombelands, Ltd., Addlestone, Surrey, for the Proprietors, Morgan Brothers (Publishers), Ltd., 28, Essex Street, Strand, W.C.2. Registered for Transmission by Canadian Magazine Post.

22
109

76
20
56
105
85
85
45
104
109

82
iii

84
83
83
102
104
82
81
70

18
16

80
102
81

104
104
115
80
104
104
102

FOCUS ON LEADERSHIP

MOULDED MICAS

STACKED MICA/FOIL
350v. D.C. Working

Type No.	Capacity in μF	List Price each
CM2ON	·0001-·0003	1/2
	-·0005	1/6
	-·001	1/9
MWN	·00005-·0003	1/2
	-·0005	1/6
	-·001	1/9
M2N (wires) MAN (tags)	·00005-·0003	1/2
	-·0006	1/6
	-·001	1/9
	-·0015	2/-
	-·002	2/3
M3N (wires) MBN (tags)	-·003	2/3
	-·006	3/-
	-·01	4/6

SILVERED MICAS
350v. D.C. Working

Type No.	Capacity in pF	List Price ea. ±10%	List Price ea. ±2%
SMWN (wire)	10-100	2/-	2/8
	101-200	2/-	2/8
	201-300	2/-	2/8
	301-500	2/4	3/-
SM2N (wire) SMAN (tags)	100-450	2/4	3/-
	451-500	2/4	3/-
	501-1000	2/8	3/3
	1001-2000	3/6	4/-
SM3N (wire) SMBN (tags)	200-2500	3/6	4/-
	2501-3000	4/-	5/-
	3001-3500	4/-	5/-
	3501-4500	4/6	5/6
	4501-5000	5/-	6/-
	5001-10,000	6/6	7/6

THESE condensers are practically indestructible even under abnormal conditions, and once fitted can be left undisturbed for years. T.C.C. Stacked Mica Condensers are interleaved with stout foils and vacuum impregnated, producing a guaranteed capacity well suited to low power R.F. conditions, etc.

In T.C.C. Silvered Mica types, distinguished by red flecked mouldings, a silvered film is fired on to the mica, resulting in extremely high stability, produced to close limits of capacity. The ranges shown are merely representative of those available.

Details of complete ranges of tolerances and working voltages on request.

TCC

SPECIALISTS IN CONDENSERS SINCE 1906

THIS UNIQUE
STELLATE CORE IS THE
SECRET OF FAULTLESS FLUXING
. . . because it gives six points of rapid solder collapse and the flux is liberated *immediately* heat is applied. The correct amount of activated flux is always present in Superspeed, thus eliminating dry or H.R. joints. The stellate core is featured only in the Enthoven range of cored solders which ensures perfect soldering.
Superspeed
ACTIVATED ROSIN CORED SOLDER
for all Radio, T.V. electronic and telecommunication soldering. Complies with M.O.S. Specification DTD. 199 and is approved by the A.I.D., G.P.O. and R.C.S.C. Superspeed is available in a wide range of alloys and gauges. Samples together with comprehensive literature gladly sent on request. Technical advisers are available for consultation.
MANUFACTURED BY THE ENTHOVEN GROUP
Published by Enthoven Solders Ltd., Enthoven House, 39, Upper Thames Street, London, E.C.4. Telephone: Mansion House 4533

1954